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PLAGUE IN NATAL

1902-3

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REPORT ON THE PLAGUE IN NATAL

1902-3

BY

ERNEST HILL

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INTRODUCTION.

TO THE HONORABLE

THE COLONIAL SECRETARY.

SIR,—I have the honor to submit a report on the recent outbreak of Plague in Natal.

The first case was discovered in Durban on December 4th, 1902, and the last case in the same town on August 15th, 1903. During this period 221 persons were attacked, of whom 162 died, a case mortality of 73 per cent. Two hundred and one cases with 145 deaths occurred in Durban, or, although found elsewhere, were certainly infected there; 2 more with 1 death, probably by matter brought from there; 7 with 6 deaths were infected in Maritzburg; and 11 natives, of whom 10 died, contracted the disease at their own homes, from 2 men infected in Durban.

Of 183 cases, which were found in one of the two boroughs or the immediate suburbs, often the nature of the illness was either not discovered until after death, or it was recognised at so late a time that removal to hospital could not be effected; 45 were found dead, no report of illness having been received, and the cause of death ascertained at the public mortuary. From this it would appear that many cases were intentionally concealed. Against this supposition must be balanced the fact that 54 of these cases were colored persons, mostly ignorant, and that 32 were characterised by an absence of Bubonic swellings, a type of the disease in which a fatal issue ensues very rapidly on attack.

The disease was in the main spread by the agency of infected rats and mice. It has been stated that complete success in the suppression of an outbreak of Plague may be anticipated from the application of measures ordinarily adopted for the suppression of outbreaks of epidemic disease, of whatever nature, under rules framed in strict conformity with the principles of modern sanitary science. Unless in the town affected all buildings have been so constructed as to afford the minimum of access and harbourage to rats and mice, and the numbers of those animals kept down, it is impossible to subscribe to such a statement. The success, which has attended prompt measures, on the lines ordinarily adopted for the suppression of other epidemic diseases, in a town here or there, is surely to be attributed in no small degree to good fortune. Had such measures only been adopted in Maritzburg it is more than probable that a considerable number of cases would have occurred.

On the spot map of Durban in the Appendix it will be seen that there is a wide area in the Point District in which Plague-infected rats were not found, and it is just possible that had no direct transference of infected matter from the wharf area to the town occurred, the outbreak might have been suppressed by the middle of February. Too much importance must not, however, be attributed to this vacant space, because the area is very thinly built over, and so there was a less chance of finding dead rats there. Whatever faint hope of such good fortune may have been entertained was quite extinguished by the discovery of infected rats in Commercial Road in the first week in January. It then became obvious that only the well recognised but quite unexplained periodicity of Plague outbreaks, whereby they come to a conclusion

in some six months, more or less, could be relied upon to terminate its course, and that the most which could be reasonably hoped was that the application of suitable measures would prove successful in keeping the number of cases within reasonable limits.

Throughout the report the use of the word "epidemic," which, though it might be legitimately applied even to the occurrence of quite a few cases of exotic disease, yet, in ordinary usage, has come to imply an extensive prevalence, has been studiously avoided as conferring too much importance on an outbreak which in seven months attacked no more than about three and one-third per thousand of the entire population of Durban, being a far less prevalence than that of Enteric Fever or Dysentery among the European portion.

The disease was, as said, spread mainly by vermin; but for all that, the measures necessary for prevention and limitation are ordinary sanitary measures, strictly applied in accordance with the principles of sanitary science, with the addition of special requirements as to the condition, maintenance, and management of warehouses, stores, and other such places, the contents of which are particularly attractive to rats. These general measures have the further advantage of being the means best calculated to reduce the incidence of Enteric Fever and Dysentery.

It would not be fitting to conclude without bringing to your notice the excellent work done by Dr. H. E. Fernandez, Dr. Murison (the Borough Medical Officer of Health, Durban), Dr. W. J. Hill, Mr. H. W. Jones and Mr. W. A. Savage (District Health Officers, Inanda, Lower Tugela, and Mapumulo Divisions respectively, in which occurred the large majority of cases outside Durban), and expressing appreciation of the valuable

service rendered by Mr. H. Watkins - Pitchford, F.R.C.V.S., Government Bacteriologist, assisted by Mr. L. G. Haydon, Special Medical Officer for Plague purposes to the Department of Public Health.

The Committees appointed in Durban and Pietermaritzburg proved of the highest value, both in strengthening the hand of the professional advisers by the support of the lay members and in inspiring confidence in the public.

It is particularly pleasing to acknowledge the courtesy of Dr. Gregory, Medical Officer of Health, Cape Colony, and Dr. Turner, Medical Officer of Health, Transvaal, in their ready offers of assistance. Owing to the kindness of the former a number of guinea-pigs and a supply of Yersin's Serum and Plague Prophylactic were obtained through the Public Health Department of the Cape. Both gentlemen put themselves to trouble to find on behalf of Natal competent Medical Officers for Plague duty.

The report is divided into two parts. Part I. deals with matters generally, and Part II., written by Mr. Watkins-Pitchford, is concerned with the experimental work and details connected with the Bacteriology of the disease.

Appendices are added containing a Map, Tables, and Charts, and a critical analysis of 124 cases treated in the Durban Hospital, for the substance of which I am indebted to Mr. H. Cockerton and Mr. F. J. Allen successively in medical charge. Dr. Fernandez prepared the excellent map and the charts.

I have the honor to be, Sir,

Your obedient Servant,

ERNEST HILL

(M.R.C.S., L.R.C.P., D.P.H. Cantab.),

Health Officer for the Colony.

PLAGUE IN NATAL,

1902-3.

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Part I.—General.

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THE HISTORY OF PLAGUE.

So much has been written on the history of Plague in the world that it is unnecessary to make any but the briefest comment on this subject. The three prominent characteristics of this disease are :—

(1) It is indigenous to and always present in certain restricted localities, where it is said to be endemic. From these endemic centres it radiates at roughly regular intervals and becomes epidemic* over a smaller or larger portion of the world. The wave of radiation may be short, or it may be long, in which case the disease is said to be pandemic. The latter are of less frequency than the former.

(2) Epidemics are markedly periodic, each in any one town lasting a period of from five to seven months, after which the disease disappears, frequently to return after an interval of from four to eight months, and that again and again. Thus the season of the year in

* The terms endemic, epidemic, pandemic, are derived from the Greek *δημος*, people, and the prepositions *ἐν*, among ; *ἐπὶ*, upon ; *πᾶς*, all : the meaning being *endemic*, among, or indigenous among the people ; *epidemic*, upon or coming upon the people ; *pandemic*, all the people—a hyperbolic term implying that a disease has extended over a large area of the globe. Similarly *epizootic* is derived from *ἐπὶ*, upon, and *ζῷον*, animal, upon or attacking animals ; and in this Report the term *epimuic*, derived from *ἐπὶ*, upon ; *μῦς*, mouse or rat, is used to designate a disease attacking or falling upon rats and mice.

which Plague prevails depends mainly on the time at which it happened to appear. The periodicity makes it a matter of importance to discover how the infection is carried on from one period of prevalence through a quiet interval to the next period. Of this no evidence has been gained except that in experimental animals occasionally the disease appears in chronic form.

(3) The disease affects rats and mice as well as mankind. The infection is interchangeable. The evidence, however, of spread from man to rat is much less prominent than the opposite. In Natal there was no evidence of such an occurrence.

The endemic centre from which the present pandemic originated is in China. The disease appeared in Hong Kong in 1894, in Bombay in 1896. It has since spread to Europe, America, Australia, and Africa. Plague appeared in Portuguese East Africa in 1899 and again in 1901, but the outbreaks were of slight consequence, and appear to have been speedily suppressed. There was a single case in Durban—in a person recently arrived from Mauritius—in 1900. The disease broke out in Cape Town in 1901 and in Port Elizabeth the same year, and has been to a greater or less extent present in the latter ever since. Early in 1903 it made its appearance in East London and other places in the Cape Colony, in which country throughout the epidemic has been wider spread than the cases in man. In the East the mortality has always been appalling, but in other parts comparatively moderate. In India the dense aggregation of the population, the overcrowding and the insanitary conditions, are such as have no parallel in the West. The most insanitary areas in the towns of Natal bear no comparison with the normal conditions of the average Indian town. In the relative sanitary circumstances lies the explanation of the fact

that Plague takes comparatively so little hold on countries where some degree of Western civilisation pertains.

THE CHARACTERISTICS OF DURBAN.

The Town and Port of Durban are situated in latitude 28° S. "The Bay" is an extensive tidal lake opening into the sea by a narrow entrance over a sandy bar. On the one side is a stretch of flat ground, entirely sand, and much of it reclaimed from marsh, of something over a mile in breadth, from which arises abruptly the Berea, a low range of hills, composed mostly of sand. On the former are situated all business premises and several hotels and many good residences, all dwellings of the poorer class and of natives and Indians other than domestic servants. On the latter the wealthier part of the European population reside, the houses standing generally in a considerable area of ground. The climate is humid, particularly in the summer months, but the mean temperature is not excessive (*vide* Chart I., Appendix). The population in 1902 was estimated at—European, 28,000; Indian, 12,500; Native, 20,000; almost all males, making about 60,500 in all.

Among Europeans actual poverty is unknown, almost all being well to do in their particular class, especially the artisans. The working class and the lower orders of European communities are chiefly, and the poor entirely, represented by the Indian Coolie and the Native, with a few half-castes.

SANITARY CONDITION OF DURBAN.

A considerable portion of the town on the sandy flat is provided with a water carriage system of sewerage; the remainder is served with pails, and the slop and bath water for the most part runs out on to the

ground about the houses, where it rapidly sinks into the sandy soil.

In parts of the borough new buildings are required to be built of brick or stone, but, even in these, some wood and iron buildings still remain, while in other parts many stores, sheds, servants' quarters, and most of the Native and Indian dwellings, are constructed of these materials, many of them of a miserable description. For all that, compared with standards of the United Kingdom, the general conditions are grossly insanitary. These unfavourable circumstances are mitigated by the absence in general of even two-storey buildings, and entirely of more than two storeys in the lower quarters of the town.

The following brief description of the sanitary conditions and system of inspection is given by Dr. P. Murison, the Medical Officer of Health for the Borough :—

Durban, at the time of my arrival twelve months past, was accorded the premier place in South Africa so far as sanitation was concerned, and a walk along any of the streets or roads gave every assurance that the popular belief was well founded.

On more careful inspection, however, and more particularly of the yards, back premises, and servants' quarters, a condition of affairs was discovered that did not coincide with the appearances from the streets. The occupiers were more or less aware of the unsatisfactory conditions existing, but the universal excuse was want of available labour. This was, no doubt, true to the extent that all labour they could obtain was employed at more remunerative work, and cleanliness was one of the conditions that had to take a secondary place.

No methodical inspection of the town was carried out by the sanitary department, and the existence of insanitary conditions was mainly brought to light by complaints or haphazard inspection.

In addition, there were some areas in the borough, such

as Bamboo Square, the Eastern Vlei, etc., which were without parallel in my experience.

For some years sewerage had been extended at the rate of, on an average, four miles a year. This was totally inadequate; but I am glad to say that the minimum is over twelve miles—probably twenty-four miles a year—since February of this year, and at this rate a few years will see the sewerage system well advanced. At the present rate, it is impossible for plumbers, etc., to make connections at the same rate, causing extortionate charges to be made to those they select for such work.

The housing of servants was in many cases of a most wretched description, and many houses occupied by Europeans were quite unfit for such a purpose. Sanitary conveniences to Indians and Kaffirs were believed to be luxuries, even for the servants of large houses, leading to nuisance and indecency. I am glad to report that such matters have occupied the attention of this Department, and the Town Council, during the past year, and it is pleasant to state that the Council have been most ready and willing to assist me in the execution of my duty.

Since last year five qualified experienced sanitary inspectors have arrived from home, and they are doing excellent work, and I feel confident that with the assistance provided, much of the reproach which I mentioned in the beginning of my letter will have disappeared. Of course, with an Indian or Kaffir population constant supervision is essential, for their ideas of sanitation are not sufficient, in my opinion, to allow them to live in any area where Europeans reside; but while such is the order of things, they will have to conform to the habits of the white men.

Durban has benefited very much *re* sanitary matters by the incidence of Plague.

To this it should be added that Indian and Native quarters are grossly overcrowded, as are also, in many cases unbeknown to the masters, the colored servants' quarters of private dwellings, even on the Berea. This is due to the accommodation provided, particularly for Native daily labourers—"Togt boys," as they are

called—being utterly inadequate for the number of such persons. Overcrowding among Europeans too is not unknown, but only in a relative degree, from the increasing population of the borough having overtaken the progress in building.

The numerous buildings of wood and iron provide easy harbourage for vermin, to the numbers of which accessions are made on the arrival of every ship. In stores which are constructed of brick and with cement or asphalte floors, the use of dunnage (boarding raised above the floors on loose joists), which arrangement is considered necessary by many merchants to prevent damage to goods from damp, favours the nesting of rats.

There is practically no paving or hardening of the curtilage of buildings, and the soil is much polluted.

The town of Maritzburg, total population about 30,000, lies on a shale formation in a basin among hills at about 2,000 feet elevation above the sea. There is no water-carriage system of sewerage, the night soil being removed in pails. The general sanitary conditions are similar to those of Durban.

Native kraals consist of “beehive” grass huts generally placed on a knoll four or five together, separated by some hundreds of yards from the nearest neighbour.

The absence of efficient ventilation favours the spread of infectious disease in the individual kraal, but the wide separation from neighbours is a hindrance to epidemic extension.

SANITARY ADMINISTRATION.

The Town Council is the sanitary authority for the Borough of Durban, which does not include the Harbour, nor a strip of land on which are built the wharves, harbour sheds, and other Government buildings.

The Town Council of Maritzburg is similarly the sanitary authority for that borough.

Under the provisions of the Public Health Act, 1901, these Town Councils have, in their respective boroughs, undivided control and responsibility in respect of all matters affecting the Public Health, subject to the proviso that if either should fail in any respect to carry out its duties, the Government may make arrangements for the proper execution of the whole or any part of those duties at the expense of the Corporation to the extent of one-eighth of the Town Revenues of the preceding year. Any expenditure in excess of this amount must be borne on the Public Revenue.

That both Town Councils had failed to take advantage of the ample powers given by the Public Health and other Acts, and had neglected to place and maintain the respective boroughs in that sanitary condition which is essential for the well being of the community in general, was abundantly evident; while it was no less obvious that they had been oblivious of the special need of setting their house in order against a visit of the much-dreaded Bubonic Plague, and had readily and completely forgotten the slight stir and searching of hearts which came with the scare on account of its appearance in Cape Town in 1901.

The Government Departments, however, were in no better case, and, for one reason or another, had neglected to provide adequate and suitable accommodation for their employés, and otherwise to make provision for maintaining premises under their control in good order.

It has generally happened that when an unusual prevalence of some ordinary, or a visitation of some new and extraordinary, zymotic disease has thrown a searching light on sanitation and sanitary administration in any place, the Sanitary Authority has been found

guilty of negligence in the past. In this respect these Sanitary Authorities came through the ordeal no better than most and no worse than many others.

SPECIAL ADMINISTRATIVE ARRANGEMENTS.

The Law provides that the Town Councils shall be responsible for sanitary administration in the boroughs. During the first month after the appearance of Plague in Durban the outbreak was limited to the narrow strip of land known as the Point, where there is some overlapping of sanitary jurisdiction. Until, therefore, the disease was found, at the end of the fifth week, to have gained a foothold in the centre of the town, Government paid the whole expenditure incurred for special purposes. The Mayor of Durban, the Health Officer for the Colony, Medical Officer of Health for the Borough, and Port Health Officer, were appointed a Committee, with authority to take such measures as might appear necessary.

It was, however, plain that at that time, on account of deficient organisation, insufficiency of staff, unsuitable methods of sanitary administration, and the general mode of municipal procedure, the Town Council was in no position to cope with emergent circumstances, wherein promptitude of action was imperative, and delay in the application of necessary measures might well prove disastrous.

It therefore appeared desirable to Government to make special arrangements. From January 10th, when it had become evident that the disease had become established in the centre of the town, Government decided in agreement with the Town Council that all matters connected with Plague in the borough should be administered by a Committee appointed by the former, and that three-quarters of the expenditure

incurred should be borne on the Public Revenue and one-quarter on the Town Revenue. Certain specified items were excepted. All expenses connected with the carrying out of the provisions of the Venice Sanitary Convention, 1897, with bacteriological investigations, and payment of compensation for property on the wharf area, damaged or destroyed, were to be paid solely from the Colonial Treasury, while all measures of ordinary sanitation, whether in clearing up arrears of work or in extending and more thoroughly performing the usual scavenging, should be a charge against the Corporation alone. It proved, however, impossible to adhere strictly to the latter condition, because in some cases there was not unanimity of opinion on the part of the parties concerned as to what constituted past neglect, and because it was essential that action should be prompt, which could only be ensured by the Committee taking such action.

A committee was appointed with full power and authority to take such action and incur such expense as the circumstances might demand. This Committee consisted of the Mayor (Mr. J. Ellis Brown, C.M.G., Chairman), the General Manager of Railways (Sir David Hunter, K.C.M.G.), the Chief Magistrate, Durban (Mr. Broome), Sir Benjamin Greenacre, K.B., Medical Officer of Health for the Borough, Port Health Officer, Health Officer for the Colony. The Deputy Mayor (Mr. Ernest Acutt, C.M.G.) was added later. Mr. Henderson, Municipal Record Clerk, was appointed Secretary, and performed the duties, in addition to his ordinary work, with conspicuous ability and tact.

Regulations, as occasion required, were made by the Governor in Council (*vide* Appendix V.).

In places outside the Boroughs arrangements were made for watching new arrivals where desirable, and

in this, and in all other respects, occurrences were dealt with under the ordinary Regulations for the purpose by the District Health Officers, under instructions from the Health Officer for the Colony. Towards the end of November, there having been no case of Plague in men or animals since August 15th, the Committees were dissolved, and the control and responsibility handed back to the Town Councils.

GENERAL ARRANGEMENTS.

The Borough Medical Officer of Health, Dr. P. Murison, took charge of the supervision of disinfection, special sanitary measures, including evacuation of certain areas, and destruction of vermin.

The Port Health Officer, Dr. H. E. Fernandez, controlled the Hospital and Ambulance Service, arrangements for diagnosis of cases, inquiry into their origin, performance of autopsies, and disposal of the dead.

The services of three medical men with previous experience of Plague in India or Cape Colony, or both, had been previously secured, and a fourth was later engaged.

A circular was sent to all medical practitioners detailing the symptoms and diagnostic points of the disease; printed slips were also issued for the guidance of the public, giving some simple information as to the manner of spread and the dangers to be anticipated, with advice as to how best to obviate the risks.

The procedure adopted was as follows:—On receipt of information of suspicious illness a Medical Officer of previous experience was despatched to visit the case, in consultation with any practitioner in attendance, if the latter so desired. A diagnosis having been arrived at, or provisionally adopted, the patient was either removed to the Plague Hospital as Plague, or suspected

Plague, or, if the possibility of Plague was rejected, left at his (or her) own home, or sent to the General Hospital for treatment. Suspects were kept apart from Plague cases until a final diagnosis was determined, when those not suffering from this disease were either discharged or kept until convalescent, according to the nature and severity of the illness in each case.

Immediately after the removal of a patient, information was transmitted by telephone to the Borough Medical Officer of Health, who made arrangements for the disinfection of the room or tenement from which the person was removed, and for the temporary accommodation of the inmates when necessary.

Hospital and ambulance accommodation for twenty-eight beds in four wards had been erected by Government on Salisbury Island in the Bay in 1901; consequently arrangements for the treatment of patients presented no difficulty. The accommodation was in excess of requirements at any time. Cases in which pneumonia supervened, persons suffering from other diseases, and suspects, were placed in tents or in the verandahs of the wards.

On the first occurrence of Plague in Mohamedans, on February 8th, the community obtained permission to erect, at their own cost, separate accommodation for their co-religionists on Salisbury Island. The work was commenced but never completed.

The nursing of European men and Indian women was performed by trained nurses, of whom several applied for appointments on hearing of the presence of Plague in Durban. Colored men were nursed by white males. Men for this purpose were selected from among applicants for employment, there being several respectable young men in Durban looking out for work—a residue of the late war. They had, in some instances,

had some previous rough training during military operations, but others were quite inexperienced. It was fortunately possible to secure the services of an ex-R.A.M.C. Staff-Sergeant and Corporal, under whose supervision the work was satisfactorily performed.

Salisbury Island presents ideal conditions for an infectious Hospital by its isolated position, and the perfect quiet and freedom from dust. The disadvantage attached is the necessity of removing the patient from the ambulance, in which he is conveyed to the wharf, to a launch or boat, and again from that, at the Island jetty, to be carried to Hospital on a stretcher. Removals after dark were in one or two instances impossible on rough nights, and the patients were accommodated in one of the office rooms till morning.

The arrangement was also expensive, because it was necessary to retain the full services of a hired launch (after the final breakdown of the water police launch which had been lent for the purpose), and to maintain a special ambulance staff of one white and two colored men. Had the Hospital been on the mainland, the Hospital staff could have been drawn on for this purpose. However, the advantages far outweigh the disadvantages of the position.

The bodies of all persons who died in Durban and of whose death the cause was not certified by a medical practitioner were removed to the Town Mortuary. Autopsy was held as soon as possible by the District Surgeon, in company with a Medical Officer from the Department, who removed specimens for bacterioscopic examination. Microscopic examination was made, and information sent to the Medical Officer of Health as to the nature of the case, as far as could be judged, and the place where deceased was reported to have resided and where he (or she) died.

At first cultures were made in nearly all instances, and several were further confirmed by inoculation of animals. Later the Medical Officer engaged for bacteriological work was transferred to Maritzburg to the Government Laboratory, where better facilities offered for research, after which cultures were made only when the microscopic evidence did not appear to warrant a definite statement. Specimens were also occasionally sent to Maritzburg for further investigation. In the tissues of forty-seven of the bodies examined at the mortuary the *Bacillus Pestis* was found. Although the presence in the *cadaver* of a bacillus exhibiting the morphological characters and giving the staining reactions of *Bacillus Pestis* would not in isolated instances justify a positive statement, yet, when Plague is prevalent, it may be taken as sufficient evidence as cause of death when present in sufficient numbers to be unmistakable.

Similar arrangements were put in force in Maritzburg from March till October, but in only three instances was evidence of Plague discovered.

In the country districts *post-mortem* examination of nearly all persons dying under suspicious circumstances was made, and when facilities offered specimens were sent to Maritzburg or Durban for investigation.

DISPOSAL OF THE DEAD.

The bodies of those who died in Durban and Maritzburg outside the Plague Hospital were buried in the Town Cemeteries. Natives in country districts were buried according to custom. There appears to be no reason why bodies should not be thus disposed of, but from the situation of the Durban Hospital it would have been necessary for the funeral parties to pass through the whole length of the town, and this was

deemed undesirable. No site suitable for a burial-ground could be found in any convenient situation. Bodies were therefore at first committed to the deep; but this arrangement was expensive, and in rough weather difficult. On this account after the middle of January they were burned on an open pyre, after the Hindoo fashion—Mohamedans, who have grave religious prejudice against cremation, were permitted to remove their dead in lead-lined coffins soldered before removal. Two corpses at different times were, owing to necessity, buried on the Island, but were exhumed and the remains burnt six months later, because the soil is unsuitable for burial, and the ground is likely to be used for wharfage in the near future.

There does not appear to be any ground for an apprehension, sometimes expressed, that there may be danger in the future from bodies buried in the soil. The tissues of one man and two guinea-pigs were examined, after burial for some months, and no evidence of the presence of the *Bacillus Pestis* in the remains could be traced (*vide* Part II.).

POPULAR FEELING.

The people in general did not at any time exhibit any marked apprehension. About the middle of January the Native population certainly took alarm and left for home in very large numbers—so much so that for a few days work at the Port was almost suspended. This was, however, largely due to the fact that the accommodation for Native labourers in the town is quite inadequate, and that private householders, who had previously not troubled themselves in the matter, now took exception to their servants receiving lodgers. Consequently many Natives were rendered homeless. It is not, however, to be denied that a panic did arise, coincident with an increase in the cases and with the introduction of cremation

as the means of disposing of the bodies of those who died in hospital. A fall in the incidence on Natives, reassurance by those in authority, and the pressure of a failing harvest speedily induced a return to work.

THE ORIGIN OF PLAGUE IN NATAL.

When Plague first appeared in India, subsequently in Mauritius, and later again in Cape Town—the last two particularly near neighbours of Natal—it was not unnatural that there should have been some degree of apprehension among the people of this Colony. The very proximity, however, of these territories, and the detailed information as to the progress of epidemics in them, is in itself, in no small degree, a safeguard against introduction therefrom ; whereas from countries more distant, and from which no direct information is received, and where, possibly, less care is observed, the danger is really greater, as proved to be in the case of the Natal outbreak.

The first case was discovered in the person of a native in the Veterinary Compound on December 4th, 1902, Plague-infected rats having been discovered there on the previous day.

In several instances, in different countries where outbreaks have occurred, it has been reported that after the recognition of the nature of the disease, an examination of the death registers, and enquiry in other ways, has brought to light the occurrence of an abnormal mortality in the few weeks preceding the discovery, and that the deaths have been ascribed to Pneumonia, Influenza, or other conditions. A scrutiny of death registers and comparison with previous years, and consideration of the records of *post-mortem* examinations made in the town mortuary, afford no evidence of such being the case in Durban.

In the first week in December the disease was found to be causing a heavy mortality among rats over a roughly triangular area of ground at the Point. The Veterinary Compound formed the apex and sheds

A B C the base of this area, which reached across the narrow strip of land. The compound is a little apart from other buildings, and there would appear no particular reason why, at this time, when the infected area was limited, the epimuic should appear there, unless it had been separately introduced. A month later the disease was found to be prevalent among rats in a large produce store in the middle of the town, quite two miles away. There was no mortality from Plague among rats in the area intervening between this store and the lower end of the Point. Infection, then, must have been conveyed to this store separately, and not by continuous extension of the epimuic.

Accordingly, it appeared that if any cargo had been landed in November on the part of the wharves, at which the epimuic made its first appearance, of which cargo portions had been conveyed to the Veterinary Compound and to this produce store, that cargo would be the most probable origin. During the month of November, 1902, only one vessel brought cargo which was so distributed. That vessel was the S.S. *Kassala*, which brought a large consignment of Lucerne hay from Argentina. The hay was discharged opposite B shed, a portion was taken to the Veterinary Compound, and the remainder, about 900 tons, to this particular store. The hay was landed about November 13th, and finally disposed of by the produce dealer by December 12th. It was removed from Durban, but no report was received of Plague in man or animals at places to which it had been sent.

It therefore seems probable that the origin of Plague in Natal was this Lucerne hay brought by the S.S. *Kassala*. The general circumstances accord with such an hypothesis, and the interval between the landing of the cargo and the discovery of the epimuic was such

as would naturally be required for its establishment. To make the chain complete, it is necessary to establish the existence of epimuic Plague on the vessel, and at the Port from which the vessel started. This evidence is wanting. That, even in the presence of an epimuic, human cases may be quite occasional is shown by many reports, and, speaking generally, no notification of the incidence of Plague among rats is reported by the countries in which it may be prevalent ; while in Natal no official intimation is received as to the presence or absence of human Plague in South America. That epimuic Plague may be present on ships without concurrent cases in man is also shown. The *Kassala* had left Durban before the outbreak occurred, and thus it was not ascertained whether there had been an unusual mortality among rats on board.

Plague may exist, to some extent, among rats in a building or enclosure without evidence in the form of dead bodies or stench from their decomposition coming to notice. An instance is afforded by the Maritzburg Brewery, where a large stack containing bottles packed in straw was surrounded with an unclimbable sheet-iron fence, to prevent rats possibly there from escaping. A long time was occupied in the unpacking of the bottles, and, no sign of dead vermin being discovered, the work was not pressed, but the fence was maintained. A month later two dead rats were found, quite fresh, and subsequently four others, all proved to have died of Plague, and one live buck, which was healthy. No putrefying remains were found, apparently because all had been eaten by their fellows. It is probable that, in such instances, as with rats confined in fair-sized rooms, the dead are eaten promptly by the living, until the corpses become too numerous.

Experimental evidence also shows that in some instances rats do not take the disease until after exposure to infection for many days. [*Vide* Part II.]

The fact, therefore, that rat plague in this produce store was not discovered till January is no bar to the possibility of its having been introduced in November.

There was no difficulty in the recognition of the disease. The writer had become familiar with Plague in India. Apart, however, from any such familiarity,

the appearance of a deadly disease among rats and the occurrence of "Bubonic Fever" in a man, and the isolation from the organs of the former and the gland juice of the latter of a bacillus corresponding in all essential characteristics with the *Bacillus Pestis*, could have left no room for doubt.*

GENERAL FEATURES OF THE DISEASE.

Plague as seen in Natal did not differ in any particular from the same disease as seen elsewhere, unless it were in the number of cases in which a definite inflammation of the lung substance was found.

Of 221 cases, in 164 buboes were observed. This gives a percentage of 74, which appears to correspond to the average recorded elsewhere. Of these 164 persons, 59 recovered and 105 died. All cases in which no buboes were observed terminated fatally. Of the cases in which single buboes were observed those of the lower extremity amounted to 65 per cent. of the whole. Of these a little more than half were entered as femoral, others being described as inguinal, implying that glands as high as the groin were involved. Twenty-eight per cent. were axillary, and 6 per cent. in different parts of the neck.

* The mere concurrence in a limited area of deadly disease among rats and domestic animals with a case of "Bubonic Fever" cannot by itself be accepted as evidence of Plague, as shown by the following coincidence. A man suffering from Plague was removed from a house in the suburbs of Durban. On enquiry into the circumstances, it was found that fowls, of which numbers were kept at his place of residence, had been and were still dying of some disease. About a month earlier some granary sweepings had been obtained for feeding the fowls. The sweepings were from an infected area. Soon after the receipt of these sweepings fowls began to take sick and die. About the same time some dead rats were found on the premises. A rat hunt was organised, and shortly after two of the dogs engaged died after a brief illness. Sick fowls were obtained, and ascertained to be suffering from Fowl Cholera. A dead dog was examined, but no bacteria found in his organs. The cause of the death of the rats was not ascertained. [*Vide* Part II.]

Of 57 cases in which no buboes were noted *post-mortem* examination was made in 45—31 in Durban mortuary. In 31 of these no definite lesion of any organ was found beyond a greater or less degree of pulmonary congestion, and of congestion of glands in some cases. The spleen was mostly enlarged and soft, but in a few instances there was no marked deviation from normal. In 25 of these the diagnosis of Plague was established by bacterioscopic examination. Cultures were not in most instances made, and from evidence brought forward in Part II. there would appear to be some room for fallacy on that account; but the cases quoted there are of the nature of curiosities, and it may be safely taken that all these cases were genuine Plague. Of the remaining 14, in 12 Pneumonia of the lobular type was found, and in 2 changes of the nature of pleurisy apart from pneumonia. In 11 of these the diagnosis was established by bacterioscopic examination with or without cultures.

Of 47 persons found dead in Durban, of whose death the cause was ascertained to be Plague, in 31* there were no buboes, and in 24 no definite lesion of any organ.

It is not at all uncommon at any time for colored persons to be "found dead," and it would naturally be expected that rapidly fatal cases without buboes would terminate unexpectedly to the associates who would not at first recognise the nature of the illness. From only 4 of the 124 cases admitted to Durban Plague Hospital were buboes absent at the time of admission, in 2 of which a bubo appeared later.

Ninety-three necropsies in all were held, and in 21 of the bodies examined a definite pneumonia was found. In 9 of these there was a bubo.

Besides these there were 12 fatal cases with pneumonic symptoms in which no necropsy was held, of which 6 were seen during life and 6 diagnosed from the

* N.B.—Included in 45 cases above noted in which *post-mortem* examination was made.

description of friends. In all these there was a history of acute respiratory distress, expectoration of blood-stained matter, and a rapidly fatal issue. In none was there any evidence of a bubo.

There were, therefore, in all 33 cases in which there was a definite inflammatory lesion of the lungs, of which 14 were of the acute sthenic type, 3 were of the asthenic type, 9 were distinctly secondary in point of time, and 7 were discovered *post mortem* in persons particulars of the symptoms of whose illness were not obtainable, and consequently cannot be classified. Pericarditis was observed at 4 autopsies, and pleurisy of different degrees at 6. There was a much heavier incidence of pneumonia than has been generally recorded, and yet for all that, as shown elsewhere, the disease exhibited but little tendency to direct spread from person to person.

Fatality was greatest in the second half of the Durban outbreak—on 85 cases between December 4th, 1902, and February 28th, 1903, 62 per cent.; on 89 cases between March 1st and August 15th, 79 per cent. In respect of very mild, or so-called ambulant, cases some details are given in Appendix IV. It is, of course, possible that some of the cases, in which the diagnosis of Plague was rejected, were really very mild cases of the disease; but if this was so, the bacillus was present in such small numbers that it could not be detected.

The incubation period in the very few cases in which there was any evidence as to the time of infection was between 48 and 72 hours. Of 11 cases in which this could be determined 8 were of the acute sthenic pneumonic type, 3 Bubonic.

The diagnosis in most cases presented no difficulty to those who had any previous acquaintance with the disease. Where there is room for doubt in Bubonic

cases this can generally be cleared up by aspiration of fluid from the swollen glands and examination under the microscope. Although, as shown in Part II., other organisms closely simulating the *Bacillus Pestis* may occur in the cadaver and in the sputum of the living, yet there seems no ground for disputing the identity of a bacillus of the accepted characteristics in the juices of a living gland. The greatest difficulty is found in those cases in which there is a diffuse cellulitis of the neck, or an adenitis associated with throat conditions apparently sufficient to account for the change, or a parotitis. In such cases the possibility of Plague may not occur to the medical attendant. All cases of pneumonia, varying in any particular from common types, should be isolated until the nature of the disease is unmistakably established.

No specific treatment proved of any avail.

COURSE OF THE DISEASE.

Epimuiic.—Apart from any continuous extension of infected area, infection was transported separately to certainly five other centres, and probably to a sixth.

- (1) Commercial Road, Durban, whence it radiated in every direction in the town.
- (2) Pietermaritzburg, South African Brewery.
- (3) Store on Musgrave Road, Durban.
- (4) Premises at the top of the Berea Road, Durban.
- (5) Malvern Railway Station Goods Shed, twelve miles distant from Durban.

From none of these did it spread further.

- (6) Store in Florida Road, Durban. Several dead rats were stated to have been found on the premises, but no opportunity occurred of examining any. One Native living there was attacked with Plague about the same time.

All the last four were detached buildings, separated from others in the neighbourhood by some yards of ground.

The disease prevailed among vermin in Durban in the shipping area as far as Cato Road during December, 1902, and January, 1903. After the beginning of February no infected specimens were encountered in this part, except at the Sewage and Destructor Works, to which infection might have been conveyed anew by refuse. Rats dead of Plague were derived at first from the lower end of the Point, later from nearer the town side. Owing to the fact that destruction by poison was being vigorously pressed, not many were examined in December and the beginning of January, but in the latter part of the latter month, and subsequently, assiduous search was made, but no dead were found.

In the town, rats dead of Plague continued to be found from January 7th to July 23rd. The course of the epimuic was as of that followed by water spilt on a dry surface: a continuous forward progression with occasional branching off shoots, and now and again a return flow. In the area between the main railway station and the cemetery it exhibited a marked persistence, returning, so to say, to attack places which had been passed over in its first progress, so that premises near together became infected at considerable intervals of time. In certain instances, too, the epimuic appeared to spread slowly in a building, and healthy rats were found therein several days after a mortality was first observed, this being contrary to the experience generally reported that rats very early depart from a building when Plague has appeared among them.

Human Plague.—The disease as affecting man in Durban followed closely on the same lines as the Epimuic.

During the first five weeks or so, from December 4th till January 9th, all the persons attacked were connected with the Point either in respect of work, or of residence, or both. After this, for a time, cases were encountered from both the Point and the Town population, and then the association with the former disappeared, giving way to the latter. The course and progress will be best appreciated by a study of the map at the end of the volume. This shows the positions of places from which 182 cases were derived, whose residence and place of work in Durban were accurately ascertained. The cases are marked against residence or place of work, according as to which appeared most probable to be causally connected with the fact of infection. Where persons are not known to have worked in any infected area, and did not reside in such, the case is marked at the place of residence.

In Maritzburg a small outbreak occurred at the time of the discovery of rat Plague at the brewery. In February 4 cases, and March 2. In May 1 case, and in June 2 cases occurred, all probably infected in or from Durban.

At the end of January, and in the middle of April, outbreaks of 4 and 7 indigenous cases respectively appeared in Native kraals.

From Charts I. and II. (Appendix I.) it is seen that there is no epidemic curve, but three maxima in January, February, and March respectively. The interval of lesser prevalence from February 21st to March 21st coincides with an apparent period of quiescence in the epimuric, during which Plague-infected rats were not found in places where many people would be exposed to any infection arising therefrom.

RELATION TO RACE, SEX, AGE, OCCUPATION AND
SURROUNDINGS OF DWELLING.

Relation to Race.—Europeans suffered very little (20 cases out of 221).

On Indians and Natives, the lower orders of the community, the stress fell differently at different times (*vide* Chart II., Appendix I.). It was a matter purely of the proportion of residents of the two races in the area infected at the time. There is no ground for saying that Indians are in general more prone to the disease, or that the habits of Indians as such in Natal conduced to it. The prosperous Mohamedan merchants proved no more susceptible than Europeans. It was a question of material prosperity, and the concomitants thereof in connection with Durban. Eighty-three Natives were attacked as against 92 Indians.

Relation to Sex.—Only two European women were attacked. They were necessarily very slightly exposed to opportunity of infection. The two resided in an area infected with rat Plague.

There are few Native women in Durban, and they mostly live as servants in the better residential parts.

Indians were attacked in Durban in the ratio 75 males, 25 females; the ratio of Indian population being 62 males, 38 females. This points to infection being more often contracted at the place of work than of residence.

Relation to Age (in Durban).—Appendix I., Table K. The numbers are too small to call for comment.

Relation to Meteorological Conditions.—Appendix I., Chart I. It cannot be said that the course of the outbreak bore any relation to temperature of the atmosphere or to rainfall.

Relation to Sanitary Conditions.—In accordance with precedent, the stress of the outbreak fell generally—though not entirely—with greatest severity on persons living in those parts of the town which are maintained least in accord with the principles of sanitary science. Where the dwellings are of the worst construction and most dilapidated, where ventilation is most deficient, where overcrowding and filth are greatest, where scavenging is least attended to, there Plague most prevailed among the residents.

There were centres in which the relations to insanitary conditions were less marked, such as Magazine Barracks, and in these centres the connection of human Plague with rat Plague was very distinct (*vide* Appendix III.).

THE MANNER IN WHICH THE DISEASE SPREAD.

An infectious disease by which man and some of the animals which frequent the haunts of man are alike attacked may spread from man to man, from animals to man, or from man to animals.

If Plague in Natal had been to any degree communicated from sick to healthy human beings, either directly or indirectly, it would be anticipated that the persons infected in this manner would be those most closely associated in domestic relations with the sick.

Forty-nine persons (Appendix I., Table A, *b, c, d, e*) were discovered suffering from Plague in places outside the boroughs of Durban and Maritzburg, and so living beyond the limits of any infected area. By the expression “infected area” is meant a more or less defined locality, whether a kraal village, suburb, or part of a town, in which there was existent Plague among rats, or in which an indigenous case of Plague

in man had occurred. Thirty-eight of these cases were primary (Appendix I., Table B), and, in at any rate 25 instances, from the fact of the persons dying or recovering in the place where they were discovered there was every opportunity for their associates to become infected. The nature of the cases, too, in 8 instances, where pneumonia was present, was such as would be most likely to conduce to spread (*vide* Table C).

Of the "primary" cases 37 were certainly infected in Durban, and 1 in or by something brought from Maritzburg. Fourteen resided in places in suburbs more or less isolated, and 24 had their permanent homes in places distinct from one another and outside the borough, and which could not have been infected in any way, other than by the persons themselves. Twenty-three were temporarily resident in Durban.

It is the custom with Natives, when taken ill, to leave the place where they are working and to go immediately to their homes in the country. Some of these 23 persons left on account of their illness, and others in the ordinary course, but, as it happened, incubating the disease. There is a constant influx and return of Natives between their kraals and the towns.

In respect of these 38 persons, then, it can be definitely stated whether or no they did infect others at the place where they were overcome by their illness, or, in some instances, their fellow-travellers by rail. Two certainly did give rise to secondary cases, and 36 as definitely did not give rise to any other cases.

In regard to those of whom it is asserted that they gave rise to no other cases, it may be objected that persons may have contracted the disease and escaped detection. This, however, is extremely improbable.

All persons, Natives included, were thoroughly on the alert for cases of suspicious illness, and these were promptly reported to the police. Several were reported at one time and another, and examined, and found to be suffering from various unimportant ailments. Further, had any such persons, associated in travelling with the sick, been attacked, assuredly a high proportion would have died, and their deaths would certainly have been discovered. But this was not so.

From these facts it is deduced that the disease had but very slight tendency to spread from man to man, even when the lungs were affected, unless that affection were an acute primary pneumonia.* But even cases of this description were not by any means always followed by other cases among their domiciliary associates. In only one of seven single instances were secondary cases traced, and in that seven followed in series.

In the Borough of Maritzburg nine cases were discovered (Appendix I., Tables A (*f*), D, E).

Only one of these cases could have been infected from a previous case in the same tenement. Two suffered from pneumonia of the asthenic type.

One hundred and sixty-three cases were discovered in the Borough of Durban (Appendix I., Table A, *a*).

There were six whose place of residence was not ascertained. Nothing can therefore be said as to their relations with previous or subsequent cases. They were either found in the street or went to the General Hospital for treatment, and there and after were able

* It is necessary to recognise two types of primary Plague Pneumonia : (1) Acute or sthenic, with dyspnœa and profuse bloodstained expectoration. (2) Asthenic. In these cases the temperature is commonly but slightly raised ; there is no respiratory distress, sputum not or but slightly bloodstained, physical signs of pneumonia may or may not be present.

to give no intelligible account of themselves. These must therefore, in estimating the possible relation of cases to any antecedent, be omitted from consideration, leaving 157. But from Table A, group *b*, 7 must be added to group *a*, as having resided in tenements in Durban, in which other residents were attacked at or about the same time (*vide* Table F, A, B).*

The number of cases, for the purpose of the present consideration, is thus brought up to 164, occupying 120 tenements. In 104 of these tenements single cases only occurred; in 16† multiple cases were found to the number of 61. Twelve of these 61 cases occurred at an interval of more than ten days after the last preceding case or group of cases in the same tenement (Table F). Seeing that ten days is accepted as the longest time over which the incubation period of Plague extends, and that all dwellings and contents were thoroughly disinfected upon the removal of each case, such instances should properly be deemed to be fresh foci, arising independently of any previous case in the same tenement. Accordingly, cases thus arising at a greater interval than ten days are considered to be for this purpose "primary" cases or groups, and the tenements in which they occurred to be separate tenements (*vide* Table G).

There were therefore 104 instances in which one

* Two other cases shown in Table F—viz. first in tenements B and K respectively—also are in relationship to Table A, *a*; but the latter is known to have been in good health when he left Durban, and the former was not taken ill till after his departure. Thus neither could have had *causal* relationship to other cases in the respective tenements.

† Three of the tenements, so described [Table F, c, o, p], really amount to eight different households, each family occupying a distinct room with a separate outside entrance, although all were under a common roof. In one instance in which six cases occurred the tenement (F) is a large compound with a number of different sheds, and the persons did not actually associate after the commencement of definite illness. Thus any direct connection between the cases is really improbable.

case, and no more, occurred, and 25 primary cases or groups (Table G), making 129 in all. That is to say, that 164 cases occurred in what are considered for the purpose 129 separate tenements, and that in only 10 of these tenements did secondary cases occur within ten days, and those secondary cases amounted to 25.

The result of this analysis of the possible origin of cases one from another is formulated in Table H, Appendix I. Of 173 potential centres of infection, 13 were possibly operative and 37 cases followed within a period of ten days after the occurrence of the primary case or group.

In the tenements A, B, C, D (Table F), in which 4 of these primary groups and 14 of these secondary cases occurred, Plague-infected rats were found. Thus there was another known source of possible infection in these instances, at least equally probable with infection from person to person. If this number of 4 centres and 14 secondary cases be subtracted there remain 9 centres which were possibly or certainly (2) operative ; 11 persons who were certainly infected from domiciliary associates sick of the disease ; and 12 for the origin of whose attack no other probable source is actually known,* except that 8 resided in an area infected with rat Plague.

* Tenements F, N, O, P were in the middle of an area infected with rat Plague ; occupants of N were stable employés—O, P, *vide* remarks Table F, *vide* note Table J. [Although from the evidence which can be reduced to figures and brought before the reader it is unavoidable that the case for and against spread of the disease from man to man should be thus presented, yet it is permissible to express a strong personal opinion, which was shared by the whole of the Plague Medical Staff, that these twelve persons were not thus infected, but that they were infected through the agency of diseased rats, although no proof of such association was elicited. There are always in the course of enquiry into the origin of cases of infective disease many slight factors which determine the verdict of the inquirer on the spot, but which cannot be formulated as evidence on paper. To avoid any appearance of a desire to bias the reader, the case is represented solely on the facts which can be brought before him.]

The conclusion is, however, to some extent weakened by the fact that instances occurred in which when a person was discovered sick or dead, some of the other inmates of the room or dwelling had disappeared. This was mostly among Indians. For all that, the most careful inquiries were made in respect of each case when there was any doubt as to the place where any person attacked really resided, and no connection with previous cases could be traced, excepting in the instances given in Table G. Therefore it seems improbable that the margin of error is wide.

Another possible factor in dissemination is to be looked for in fomites* removed from a dwelling in which a case of Plague had occurred. Although there was not intentional concealment of cases to any great extent, yet, on occasion, the occupants of a tenement, particularly Indians, were prone to panic, and doubtless in some instances did remove some of their effects when an inmate of the household was taken ill. But the most diligent inquiry by competent men selected from the police for the purpose failed to establish the details of connection of cases through such means, and the number of persons so infected was probably very small.

In respect of dissemination by fomites, there were 8 cases the origin of which is only explicable on the hypothesis that the infection was conveyed in this manner or by infected articles of food (*vide* Appendix II.).

* By "fomites" is meant articles of clothing, bedding, and such-like things in domestic use, which might become vehicles of infected matter, either from being used by a person sick of Plague, or soiled by rats suffering from that disease.

Connection between Human Cases and Rat Plague.

—The connection is best shown in the following Table I.

<i>Removed from houses or buildings or working in buildings where</i>	<i>Number of Cases.</i>
1. Rats known to have died of Plague	56
2. Rats known to have died, but specimens not examined	7
*3. Rats in other places in immediate neighbourhood known to have died of Plague	104
4. Rats in other places in near neighbourhood not known to have died spontaneously.. .. .	42
5. Rats known not to have died of Plague anywhere near	12
	221

* It is a matter for regret that detailed search was not in all cases made for the presence of dead rats on premises. Reliance was placed on absence of external evidences of their presence in conjunction with the statements of the occupants. Had the floors been invariably taken up and wood lining, etc., removed, it is possible that in more instances carcasses would have been found in the places where the persons lived or worked.

Of the 42 cases entered in Section 4, 6 were persons not identified, owing to death supervening on discovery without any lucid mental interval intervening. Of the remainder, no rats are known to have died in or near their places of residence, and inquiry failed to establish any definite connection with rat Plague at the place of work. Three were of the crew of the S.S. *Zingara*, and 3 were Natives found outside the boroughs, whose place of residence or even the neighbourhood in which they worked could not be ascertained. Eleven of the 12 persons in Section 5 were resident in the country, and 1 in the suburbs of Maritzburg.

In Maritzburg from among 9 cases, 4 worked in one way or another for the South African Brewery. Two cases occurred on February 25th, one found dead on the 27th, and one on March 28th. Plague-infected rats were found at the end of February and again at the end of March in another part of the same premises,

but nowhere else at any time in the town. It is not a little remarkable that while on these premises alone were Plague-infected rats found, and while 4 out of 9 persons attacked in all were definitely connected with these premises, yet in three instances, at any rate, their connection was not such as would be expected to bring them into particular danger from this source. Of the first three, 2 were carters, whose sole business was to convey cases to and from the premises, and not to load or unload, and the third is stated to have been dismissed a fortnight before his death, which followed on a few hours' illness. The fourth was employed in the engine-room. The third had possibly revisited after dismissal. Among the regular employés of the company no cases of Plague were detected.

In Durban, between December 4th, 1902, and August 15th, 1903, 554 rats brought in from 177 different places were examined. Of these 86 coming from 46 different places were found to have died of Plague, the remainder having died of poison, violence, or other causes. In 14 of these 46 places Plague in human beings shortly after or at the same time occurred, while of the 131 from which rats not infected were received, from only 6 were cases reported.

The observation of the course of the epimuric was rendered very difficult both by reason of the fact that rats were being systematically poisoned during the whole period (it was impossible to examine all found dead), and also because Natives and Indians, and others for that matter, threw any dead rats found into the nearest rubbish bin and did not hand them over for examination, and in not a few instances probably wilfully concealed the fact that rats were dying spontaneously on their premises.

On the discovery of infected rats in any building it was immediately disinfected and cleaned up, which may account for the fact that from 30 per cent. only of such were cases among men subsequently reported.

A study of the spot map appended shows in the main a marked correspondence of locality between rat Plague and human Plague. Certain parts show considerable infection with rat Plague and several cases in man; others show a freedom from both. There are two portions of the town, however, in which the cases group thickly, but the indications of rat Plague in the actual premises are absent. These are Brickhill Road* and a portion about the cemetery. In respect of the first named, the road is devoted to stables, and it is quite possible that dead rats were removed with the stable litter and very improbable that the residents—mostly Natives—would have volunteered or even accorded information on inquiry. It will be observed that premises in which infected rats were found are marked in the near vicinity. The latter is an overcrowded portion populated mostly by Indians, of a class who would be most likely to conceal, or at any rate not to reveal, rat mortality. And here again it will be seen that infected rats were found in premises not far distant, and that on one occasion an infected specimen was found in the middle of the part most affected.

In this connection the number of cases occurring round about the cemetery is notable. It would appear to be a coincidence, for although the Town Mortuary is situated in the middle of the graveyard and numbers of bodies were examined there and the cause of death found to have been Plague, yet the cases did not begin to appear till some months after the commencement of the outbreak, and ceased some time before its final close; and the side on which most cases occurred is that from the direction of which the wind most commonly blows. This area is one of the most insanitary and probably the most overcrowded in Durban.

* Table F, Tenements N, O, P.

On the connection between Plague among rats and among men some light is also thrown by a study of the occupations of those affected (Appendix I., Table J). Of the total cases (221), 49 or 22 per cent. were employed in produce stores or stables. These persons, by reason of their occupation, would be especially exposed to any infection carried by rats, such places being particularly affected by vermin.

Seeing that eleven of the total (221 cases) were infected at native kraals and three were children under five years, and that such persons were exposed to no possible source of infection, excepting in their homes, the proportion of stablemen and produce store employés among those exposed to the dual chance of infection at home and in place of work is really higher than 22 per cent.

Twelve of the persons attacked were engaged in ordinary sanitary work, but no special note is taken of this, because they all lived in those barracks of the Corporation in which rat Plague prevailed. The Medical Officer of Health, Durban Borough, one rat-catcher, and two disinfecting coolies (Table J. Sanitary Special), and the mortuary attendant, may be deemed to have been infected in the course of their special duties.

In respect of possible infection through articles of food no evidence is forthcoming. Possibly the conditions found in the livers of the three members of the crew of the S.S. *Zingara* might be taken to point in this direction (*vide* Appendix IV.).

In dealing with colored races there is always much difficulty in obtaining the full and detailed history of their movements and associations, which can be obtained from Europeans by their own fellow-countrymen. This difficulty is accentuated when, as in Natal, the colored population comprises persons of several races with different languages—Kaffirs, Pondos, Zanzibans, North-country Indians, South-country Indians.

Even when a competent interpreter can be found—which is only occasionally—the results of inquiry at second hand lack precision.

TABLE M.

Summary of probable source of infection or influence of residence or occupation.

	Source.	No. of Cases.
1	* "Contact" (includes 3 stablemen)	23
2	Fomites or food	8
3	Special Plague duties †	5
4	Premises known to be infected with rat Plague, including 26 produce store and stablemen.. ..	56
5	Premises probably infected with rat Plague	7
6	Premises in area infected with rat Plague—produce store and stablemen, 20 ; others, excluding 5 in (3) and 8 in (1), 69	89
7	No evidence of any of foregoing	33
	Total	221

* From a knowledge of the circumstances it is tolerably certain that this estimate even is too high, but as there is no direct evidence of some of these persons being exposed to infection from rats they are included among persons possibly infected by contact with other persons sick of the disease.

† Medical Officer of Health, rat-catcher, mortuary attendant, and two disinfecting coolies.

Taking into consideration all the facts given and summarised in Table M, there would appear no reason to question that the most important agency in the dissemination of Plague was the rat. Of infection of domestic animals there is no particle of evidence.* Contact with other cases played quite a subsidiary

* The experimental work conducted in Natal gives no support to any theory that "farmyard stock" is any way involved as an agent in the spread of Plague. Immediately after publication of the Report of experimental work in Hong Kong, most careful investigation was instituted on similar lines, but the results given in detail in Part II. do not in any way confirm the experience there encountered. The experiments with excreta indicate that the *Bacillus Pestis* did not survive passage through the intestinal tract.

rôle, while the part taken by fomites was of minor importance.*

In respect of the means by which infection was communicated from rat to man, whether by the medium of excreta or by the intermediation of insects, but little evidence could be gathered. That Plague *can* be conveyed from sick to healthy animals by fleas is shown by a few experiments published by different observers. That it can be acquired by rats in and from a building infected by rats artificially infected, apart from the ingestion of their dead predecessors and without the intermediation of fleas, is shown in Part II., Appendix B, Granary 6, where, although fleas had been searched for on the infected rats and not found, yet after removal of all dead, fresh rats when turned into the box contracted the disease, and that after the application of sulphur dioxide and paraform in higher proportions than those usually adopted for disinfection. As to epidemiological evidence, on 9 patients out of 124 admitted to Durban Plague Hospital superficial skin lesions were detected on admission, which might have been the seat of entry and might have originated in insect bites (*vide* Appendix V.), and very probably other instances of

* After the completion of this Report, two cases occurred within a period of five days in Maritzburg—after an interval of over five months from the last previous case in the town, and over three months from the last case in Durban. In both towns during almost the whole time a bacteriological examination of organs taken from the bodies of all persons the cause of whose death was not certified by a medical practitioner was made. It can therefore be confidently asserted that there were no intermediate cases in man. No probable source of infection could in either case, nor could any possibility of connection of the two cases with one another, or a common source, be established. In the second case ulceration of Peyer's patches was found, the condition closely simulating Enteric. The *Bacillus Pestis* was found in the spleen and fully identified. There would appear grounds for deeming this man to have been infected through the medium of food. If this were so, it is strange that the bacillus was very sparsely present in the liver. The spleen juice had no agglutinating effect on cultures of the *Bacillus Typhosus*.

insect bites may, on account of the difficulty of detection in colored persons, have been overlooked.

However strong the reasons may be for concluding that Bubonic cases are infected through the skin, there can be no such reasons for assigning the same mode of infection for cases in which there are no buboes. Out of 221 cases discovered in Natal in the period considered, in 57 no buboes were noted. There is, then; no ground for assuming the intermediation of insects in these 57. They must have been infected in some other way, and the only apparent way is through the mouth or nose, or by particulate matter in the air or in articles of food. Further, in three instances it happened that where multiple cases occurred in the same tenement or kraal, some of the cases were Bubonic and others Pneumonic in type, and in two of these instances all the persons affected were taken sick on the same day, and presumably infected at the same time.

(1) House in Pine Street, Durban. On February 8th two dead bodies were found in the house and one person dying of characteristic Pneumonic Plague of acute sthenic type. Of the two dead who were examined, in one a bubo was found, in the other no bubo; in both the usual signs of acute infective fever, congestion of internal organs, and petechial hæmorrhage into serous membranes. A fourth person who had lodged in this house for a few days preceding his departure on February 4th to Richmond, where he arrived in good health, became ill on the 6th and died on February 8th of Bubonic Plague. A fifth man was discovered on February 21st having a suppurating bubo in the groin. He had left the house in Pine Street on February 7th or 8th, and retired into hiding in the suburbs, and having recovered from his acute illness, returned to his old haunts, where

he was detected. These five persons would appear to have received infection from the same source. In three there were buboes, in two none, one of them suffering with Pneumonia.

(2) Two carters in Maritzburg, taken ill same day, infected presumably from the same source at the same time ; in one there was a bubo ; in the other no bubo existed, but *post mortem* pneumonia, which had not given rise to prominent symptoms during life, was found. In both instances there is every reason to suppose that rats were the agents of infection, but in those whose lungs were affected certainly, and in the other non-bubonic case assumedly, the infection was taken in particulate matter with the air. Assuming the presence of the bacillus in the air for the infection of three cases, is it necessary to suppose the intermediation of insects in the other four ?

(3) At a kraal in Mapumulo on January 23rd a man arrived and died the same night. There is no evidence as to whether he presented symptoms of pneumonia or no. Thereafter the following cases were reported :—

- (1) January 31st, Bubonic—died February 4th.
- (2) February 3rd, Pneumonic—died February 4th.
- (3) February 5th, Bubonic—died February 8th.
- (4) February 5th, Bubonic—recovered.

Case No. 2 must presumably have inhaled particulate infective matter. It is certain that there were no rats infected either before or after these occurrences at this kraal, and so it is of no moment for present purposes whether the initial case was pneumonic or not, for the infective matter was derived from that case, and gave rise to Bubonic Plague, 3 cases ; Pneumonic Plague, 1 case. Is it necessary to assume

an intermediation of insects in the infection of the three ?

In respect of the remainder, in which there were no buboes, 8 formed a typical series of characteristic Pneumonic Plague in a kraal where no rats were attacked either before or after; in other 8 the existence of pneumonia was discovered at the autopsy, and no history of symptoms was available; and in 4, symptoms of pneumonia were the salient feature. In 2 others pneumonia appeared early in the course of illness combined with liver changes—in one of which a bubo developed later. Of these 20 in which pneumonia was the principal feature either of the illness or at the necropsy, 2 only occurred in the same tenement as a Bubonic case. Of those in which neither bubo nor pneumonia was found in two instances such cases concurred with bubonic (1 and 1 and 7 and 8 cases respectively) and in 1 with a pneumonic case. The remainder were isolated cases.

In these 57 non-bubonic cases, infection was apparently acquired without the intermediation of insects through the respiratory or alimentary tract. To reach those tracts it must have existed for the time independent of any living host, and therefore might have come into contact with the skin as readily as with any other part of the body; for the bacillus to gain entry through the skin there is needed a breach of surface; but published experiments show that careful shaving of the abdomen of a guinea-pig, though producing no lesion visible to the unaided eye, yet causes a breach sufficient to permit the entry of the cultivated bacillus when rubbed on the shaved surface. Now the bacillus of Plague leaves the body of the rat in secretions from the naso-oral cavities and in the excreta: the occurrence of cases of Plague with-

out buboes, and particularly with pneumonia, shows that the bacillus can thus gain access through the atmosphere to the surface of the body and so become infective, while the mere rubbing of the leg with rough clothing will, especially in warm weather, produce a breach of surface quite equivalent to the effect of shaving. This being so, it does not seem essential to seek for the intermediation of insects in the production of all cases of Bubonic Plague, though probably enough insects may take their part as one of the agents of dissemination. In Part II. it is reported that fleas on rats were very scarce in Maritzburg when Plague was absent. This accords with similar observations in Sydney, 1902, as reported by Ashburton Thompson.

In respect to the infectious quality of Pneumonic Plague, the following are facts worthy of note. During the outbreak, among primary cases—that is to say, cases not following in any tenement in a period of ten days after a previous case—there were cases in which pneumonia was the salient feature of the illness, 8; cases in which pneumonia was discovered *post mortem*, 8; there being no clinical history in 3, and no evident signs of life in 1, and no history available at all in 4. Of these, 1 case gave rise to a series of 7 pneumonic cases in succession; and 1 was followed by a similar case four days later (S.S. Zingara, *vide* Appendix V.), but it was adjudged that possibly infection arose from one common source. In a third instance a pneumonic case occurred as one of a series, but there was no evidence on which to base a statement as to the character of the primary case. No connection with any subsequent case could be traced to 14 primary cases in which pneumonia occurred, and in 6 of which it was the most prominent feature of the illness. From which it would appear that, except

under the most favorable circumstances of want of light and air and overcrowding, Pneumonic Plague may prove to be much less infectious in quality than is generally anticipated.

As to possibility of food infection, there were 5 cases in which the parotid glands were inflamed, and 3 in which an inflammation of the tonsils was observed.

There were also 3 cases in which the liver was markedly affected, while the *Bacillus Pestis* was very scanty in the spleen. It is interesting to note in this connection that Hetsch and Otto in their experiments in feeding rats with Plague material* found the bacillus present in the liver in greater numbers than in the spleen, and that there was evidence in other cases of its having gained entry through the mucous lining of the mouth or fauces.

As to the manner in which the interval between epidemic and epizootic outbreaks are bridged, the experiments reported in Part II. do not encourage any belief in the persistent existence of the bacillus outside a living host, whether in the earth or in buildings, but the scanty instances there related in which the disease appeared to have assumed a chronic form, the organism retaining its virulence, support the supposition that it may be carried through the quiescent period by such means, but throw no light on the further conditions necessary for its re-establishment in epizootic form. The bacillus died out in soil in five weeks, and in buildings full of produce in between four and eight weeks.

* *Journal Tropical Medicine*, October 15th, 1903.

MEASURES FOR THE LIMITATION OF PLAGUE.

The measures at command are :—

- (1) Destruction of rats and mice.
- (2) Disinfection of infected and probably infected buildings.
- (3) Isolation of the sick.
- (4) Regular and thorough scavenging.
- (5) Evacuation of infected areas.
- (6) Preventive inoculation.
- (7) Segregation of contacts.

The relative value of these measures in combating any particular outbreak depends much on its character. In a severe epidemic, or where the general circumstances suggest a probability that a considerable proportion of the population will be attacked, general inoculation would be the most effective. The circumstances which would suggest such a conclusion would be particularly a gross degree of general overcrowding both of buildings and of area. On the other hand, where cases are comparatively few and generally scattered in distribution, and the town is not in general thickly populated, on account of which the risk to each member of the community is comparatively not great, their value would appear to stand in the order given.

Scavenging should, of course, be regular and thorough at all times, but seldom, if ever, is so. Its importance, among other things, lies in the removal of that which attracts vermin.

(1) *Destruction of Vermin.*—The very marked connection at the outset between Plague among rats and among men made it apparent that the most important measure in the control of this outbreak was the destruction of rats and mice. In respect of methods the choice lay between offering a reward for rats brought in, and organising arrangements for trapping and

poisoning on a considerable scale. It did not seem advisable to adopt the former in Durban, because it would then have been necessary for numbers of rats, many of them probably dead of Plague, to be carried about by the various persons who became possessed of them, and brought to the receiving place for payment. Thus a certain risk of disseminating the disease among those persons, and possibly others, would be incurred. A gang of Europeans was therefore continuously employed for the destruction of vermin. Large numbers were destroyed, mainly by poison—chiefly by arsenic and phosphorus.

In Maritzburg the Town Council had for two years past been paying a small reward for dead rats, which had kept the numbers to some degree in check. A few weeks before the appearance of Plague in the town the reward was increased, and on the occurrence the amount was raised to sixpence a head, a sum sufficient to act as a considerable incentive to ingenuity. Between February and August, 1903, 24,000 were received at a cost of £500. It is not improbable that the arrest of the outbreak was in no small measure due to this. The money may well be regarded as bringing in as good a return as any expended.

Seeing that Plague among rats in Maritzburg was limited to the one place, the objections which existed to the reward system in Durban did not hold.

There is no doubt that, unless the services of thoroughly reliable and conscientious men are available, the payment of rewards produces a better result. Such men could not be enlisted in Durban.

A number of complaints were received of stench in private houses and business premises, in consequence of which it was necessary to take up floors and remove wainscotings.

In the early part of 1901 several tubes of culture of Danysz "rat virus" were obtained, but the results of experimental work were not encouraging, and a sample received later from Cape Town gave no better results after its arrival. Consequently it was at no time employed.

ENCLOSURE OF INFECTED PREMISES.

The appearance of rat Plague at the Maritzburg Brewery and its apparent absence from any other premises afforded an opportunity not obtained in Durban, owing to the rapid diffusion of the epimuic, for taking special measures for its suppression. The granary, in which infected vermin were found, and adjoining portions of the premises were promptly fenced with corrugated iron in such a manner that no rats could escape. The contents were turned over, the bags sprayed with formaline solution, the floors thoroughly disinfected, and all vermin destroyed. In one enclosure between 20 and 30 and in the other some half-dozen dead or live rats were found. A small wooden building hard by was burnt, and all vermin escaping the flames killed. No infected rats or mice were subsequently found in the town. Of the 5 cases in man discovered after this, 1 occurred a few days later, of which the source was not discovered, unless it were contact with a previous case (*vide ante*, Section II); 1, some three weeks later, was a brewery employé;* and 3 occurred much later, 1 certainly and the other 2 almost certainly infected in or from Durban.

Measures of this description are obviously applicable only on the first appearance of rat Plague in any town

* At the time when this death occurred there were still some infected rats in one of the enclosures, as subsequently discovered, and this individual may have entered that enclosure for some purpose.

and when the epimic area is strictly limited. In such instances it is the most important of all measures.

(2) *Disinfection*.—All granaries, stores, and such-like places were frequently inspected, and whenever rats were ascertained to be infected the building was thoroughly disinfected, and the best feasible means applied to the contents for the same purpose.

There is evident risk in handling the contents of stores, among the rats in which Plague is prevalent. The risk, however, appears somewhat uncertain in its action (*vide* Appendix III.). Only one mishap occurred, and in that case the infection was very gross and no special precautions were adopted. In most instances where it became necessary to remove such goods the bags were lightly sprayed with formaline or other non-poisonous disinfectant before handling, and the floors swabbed as each portion was exposed.

From certain experience gained in the epidemic at Karachi in 1898, when, after houses had been closed for some weeks, on being reopened the floors were found strewn with the bodies of dead rats, already mummified, the bacillus could not be isolated by the medical officer detailed for inquiry from the dust, sacks, or other contents, it appeared likely that lapse of time might under favorable conditions be an important adjuvant to disinfection, and it appeared worth while to test this opinion by means of direct experimental evidence. A row of granaries was therefore built in which produce might be stored under an exact imitation of the ordinary commercial conditions. As a result it was found (Part II.) that although at the period of one month from the death of the last rat healthy rats, when exposed, did contract Plague from the surroundings, but that at the period of two months they did not become infected, and that the use, in the proportion per cubic space usually laid down, of gaseous disinfectants did not affect the results. It is to be supposed then that the bacillus when separated from a living

Undergoes a rapidly progressive loss of virulence during the fourth to the eighth weeks of such separation. The opinion that such was likely to happen had been proved on in some instances. It would now appear that, if on the discovery of rat Plague in a granary all rats could be destroyed by the generation of sulphur dioxide or other irrespirable gas, future ingress of the newcomers prevented, and the granary closed for some five or six weeks, the possible risk of handling the contents, even when disinfectants were used, would be much diminished.

All houses in which cases of Plague occurred were treated with chemical disinfectants, and all clothing, etc., exposed to saturated steam in a portable Thresh disinfecter.

In particularly infected areas routine disinfection of all dirty, ill-kept, or dilapidated buildings was carried out from time to time.

Slips were issued to householders pointing out the danger from rats and inviting co-operation in their destruction, urging the covering up of garbage, and suggesting regular washing with insecticide disinfectants of floors of servants' quarters, etc.

(3) *Isolation of Sick*.—All persons sick of Plague were removed to hospital, and those who recovered detained for not less than four weeks. Despite the scanty evidence of spread from man to man this would be always advisable, both to facilitate immediate disinfection, and to prevent, what must be regarded as a certain risk, the infection of surroundings by the dying.

(4) *Scavenging*.—A large number of extra coolies were, by favor of the Indian Immigration Trust Board, under the urgent circumstances allotted to the Corporation of Durban, and the general sanitary work much improved. The sanitary department was pre-

viously undermanned, and, had it not been for this timely aid, a more serious situation might well have developed.

(5) *Evacuation*.—The value of this time-honored measure is unquestionably great. Three areas were thus dealt with in Durban.

After the occurrence of 8 cases the area known as Bamboo Square was cleared, and all the wood and iron buildings and shanties demolished.

After the occurrence of 9 cases, Brickhill Road was cleared of horses and men for about six weeks pending thorough cleansing, alterations and improvements of stables and the erection of suitable house accommodation for the men. Six cases occurred among persons previously resident there in the following ten days, but none later.

After the occurrence of 4 cases, the Indian Immigration Depôt was removed outside the town. One case occurred after the order was issued, and 1 just after arrival of the occupants at the new temporary site.

The inhabitants of Bamboo Square moved mostly to the outskirts and suburbs, and no subsequent cases were traced among them.

Numbers of wood and iron shanties and hovels, which ought to have been demolished years before, were also closed and pulled down.

The circumstances which render necessary the adoption of an expedient so drastic and so harassing to the persons affected were such entirely as had arisen from previous sanitary neglect. Whatever difficulties may arise in old-established cities in dealing with insanitary areas, no excuse whatever can be found for a young town which permits such conditions to grow up in its midst.

(6) *Preventive Inoculation*.—The value of inoculation with material prepared by Haffkine's method, as a

protective agent, is beyond question, and in the presence of a severe epidemic the measure is of the first importance for checking the extension. Where the cases are sporadic merely, the position is different. Advantage would be derived from inoculation of persons residing in an area around a fresh focus, but even then the local outbreak can be more expeditiously dealt with by evacuation and provision of temporary accommodation, and that with less disturbance, in the case of colored employés, of the daily work.

Prophylactic inoculation was not resorted to, for the reason that to produce any result it would be necessary to inoculate a large proportion of the entire population, while the very modest limits, to which this outbreak at any time attained, did not call for or justify such a measure.

Yersin's serum was employed as a protective measure in one kraal, after 6 cases of Pneumonic Plague had occurred. Two persons were subsequently attacked, of whom one was taken ill on the day of inoculation, and the other, who alone had not been inoculated and who had attended the last case, died six days later after a three-days' illness. In the face, however, of the apparent inefficacy of this serum as a remedial adjuvant, caution is necessary in ascribing to its use the termination of this outbreak.

(7) *Segregation of Contacts*.—By "contacts" is intended domiciliary associates of the sick, who may or may not be working at the same place with them, whether at the premises where they reside or elsewhere.

Contacts were not systematically segregated. The reasons assigned at the time for departure from the general practice were:—(1) The disease is not spread to any great extent from person to person. (2) Among

contacts, excepting where the case is of the acute pneumonic type, quite a small percentage develop the disease by reason of such contact. Segregation therefore means a very large amount of inconvenience to persons directly or indirectly concerned for a very small result. (3) The system of segregation being objected to by healthy persons, especially Natives, fosters concealment of cases, and is therefore (4) likely to defeat the object in view—viz. to secure fresh cases as early as possible before the infection becomes generalised in the body with the approach of death, with a greater likelihood of dissemination.

When cases occurred in native kraals, however, the kraal, or collection of huts, was placed under "quarantine" restrictions, and communication with the outside world cut off, because this was comparatively easy, and involved no loss nor disturbance of business.

In one instance (Table F, Tenement B), after the occurrence of the first group of 4 cases at a produce store in Commercial Road, Durban, instructions were issued to keep under detention and observation the remaining inmates who resided on the premises. Owing to an unfortunate misunderstanding they were allowed to get away four days later. On that day three of them were prevented by sickness from leaving the temporary camp, and one was found in a loft in Durban. The remainder were taken with a not unnatural panic, and decamped for their own homes, which some reached, while others died on the way. In the following four days information was received from country districts of the death of four and the illness of two more, who subsequently recovered.

It had been the original intention to segregate contacts when the primary case was pneumonic, or when a person had died in a crowded room. Of the former, however, only two instances occurred among persons discovered sick of the disease in Durban itself. In the one case the contacts were adequately segregated for all purposes at the borough Destructor Compound where they resided, and in the other no persons were found in the house, excepting two dead bodies. It was subsequently ascertained that two more persons were taken

ill about the same day, one of whom died at Richmond, and the other was some days later found at Sydenham and removed to hospital, but that no other frequenters of the place, an Indian restaurant, were attacked (Appendix I., Table F, κ). In a third instance the occurrence of an unrecognised case of Pneumonic Plague seems probable, for on the discovery of a Bubonic case it was elicited that a member of the household had died a week previously, and been buried under a medical certificate of pneumonia. There can be no excuse for failure to report such a case. No other cases, however, followed in the house, and diagnosis of Plague is only surmise. With regard to persons found dead, it soon appeared that the anticipation of being removed to a segregation camp would probably cause the associates to disperse. Further, as time went on, no special danger seemed to be connected with such cases. It was, therefore, preferred to secure as effective an observation over the contacts as possible without segregation.

In respect of what did actually happen, there were 13 instances in which the occurrence of a case (or two or three of simultaneous onset) was followed by the appearance within a period of ten days of other cases among domiciliary associates, and the number of such cases was 37 (Appendix I., Table H). It has been earlier shown that for 14 of these cases there were other sources to which infection could with stronger reason be attributed than to contact with previous cases.

However that may be, it remains that 13 (7.5 per cent.) primary groups were followed within ten days by other cases, and that these cases, so arising, amounted to 16.7 per cent. of the total number. It is well, therefore, to take closer scrutiny of these 13 groups with a view to ascertaining whether in all or any there were

any special circumstances to which weight may be given in dealing with future occurrences.

The tenements occupied by 4 of these primary foci, which were followed by secondary cases, and by 1 which was not, were infected with rat Plague (Appendix I., Table F, A, B, C, D). In Durban, as previously stated, from 14 places only were infected rats and patients both received. Thus, in 5 out of 14 (or 35 per cent.) of the places in which there was positive evidence of rat Plague, and in which cases of human Plague also occurred, the cases were multiple. It is not to be inferred, however, that because infected rats were not received from other places, from which single or multiple cases were reported, those places were necessarily not infected with rat Plague, but what may, to some extent, be inferred is that rats were more numerous in these places, and so attracted more attention after death. This was very markedly the case in Tenement B, Table F. In Tenement K all the cases were practically simultaneous. No rats were found in the house, but the next-door neighbour stated that he had frequently found dead rats on his premises about that time, and had thrown them into the rubbish box. (The place, a wood and iron building in bad repair, was burnt down.) N, O, P were situated all in close proximity; in O, P the incidence was on different families, though under one roof, and therefore not in the strict application of the term contacts. Infected rats were found in the neighbourhood both before and after the dates, and other single cases arose among persons living in the locality, and after evacuation the cases did not continue among the residents who were working for regular employers and therefore under effective observation. Of the secondary cases in kraals, one series of 7 was started by a pneu-

monic case, and all of the series presented acute pulmonary symptoms. The majority of secondary cases among contacts, then, in which close association with primary cases is established, were connected either with a marked mortality from Plague among rats, or with acute Pneumonic Plague. This being so, and considering the loss, direct and indirect, arising from segregation,* it appears neither necessary nor desirable to segregate indiscriminately all persons who have been "in contact" with infected man or infected rats—and the two must certainly be placed on a level, even if preference is not given to the rat as a carrier of infection—but rather that a discriminative selection, taking each instance on its own merits, will meet all the needs. Where there appears either on account of exceptional exposure† owing to the number of infected rats found, or by reason of clinical manifestations of pneumonia in any case, especial cause for anticipating the occurrence of further cases, contacts may with advantage be kept under control; in other instances they can be sufficiently observed without removal when working for regular employers, while there is always some degree of uncertainty, in respect of Natives and Coolies, as to what persons have been in domiciliary association with persons not living on the premises of a regular employer, and the prospect of rigid segregation would the more incline such to conceal the fact.

Contacts, if decamping, can generally be traced, even in a mixed colored community, but frequently

* Segregation of contacts in some cases would have meant removing from work for a single employer as many as forty or fifty men, living in a large barrack room.

† It is necessary to qualify the mere fact of exposure, by which is meant the discovery of one or more infected rats in the place of residence or work, because of the numerous instances in which there is known to have been exposure, and, indeed, in one exceptional exposure, without any cases resulting among the exposed.

not until the average incubation period of three or four days is past. Any attempt then to secure "contacts" in such instances for purposes of segregation would be at the best but partly successful; and it is more satisfactory to *know* exactly who was actually in contact than to secure a part only of such.

The object of segregation is to secure that persons incubating the disease shall have no opportunity after the onset of infecting others. This mode of transmission would appear to be occasional rather than constant. Against the advantages have to be balanced the disadvantages. They are (1) expense of maintenance, (2) disturbance of trade and dislocation of work, (3) the dislike of segregation among contacts in many cases defeating its own object.

Balancing the one against the other, the scale turns against general indiscriminate segregation.

On the occurrence of the first case of Plague in any place, and where there is no evidence of rats being infected except on any premises, where there is a chance of preventing the extension of an epidemic it is advisable to segregate all contacts for a few days, particularly with the object of more effectually disinfecting all the effects, and so preventing rats from becoming infected therefrom, as may possibly happen.

THE PREVENTION OF SPREAD TO OTHER PLACES.

Plague may be carried from one place to another by :—

- (1) Infected man.
- (2) Fomites.
- (3) Infected vermin.
- (4) Grain, hay, forage, or such-like articles, of which (1) and (2) and (3) and (4) are interdependent.

In regard to the possibility of the disease being carried in ships from Natal to places oversea. The Venice Sanitary Convention of 1897, while making very precise provision in respect of the action to be taken in infected territories, with design to prevent the carriage of infection of Plague by man and his impedimenta, or by merchandise, takes no cognisance at all of the dangers from infected vermin. In the light of the extended knowledge gained since that date as to the manner in which Plague is nearly always carried oversea, this is a grave defect. In the present state of information it is justifiable to say that the risk from man and his impedimenta is insignificant beside the danger from rats and mice, and articles infected by them. In so far as concerned Natal, the examination of passengers might, without any appreciable risk, have been omitted. Natives scarcely travel at all by sea except to Cape Colony. The Cape Government decided to refuse admission to Natives and Indian passengers from Durban, and they were accordingly not embarked for those ports. Coolies returning to India were, after the end of January, collected at the temporary dépôt outside the town and thence taken straight on board. Of the few Europeans attacked during the outbreak nearly all were of the working classes, who have not the opportunity of travel, while the class who do voyage are those who, by reason of their circumstances of life, were neither in their persons nor their effects exposed to chance of infection.

However that may be, throughout the period of the outbreak all passengers and crews were, in accordance with the provisions of the Convention, examined at the time of embarkation, and, when desirable, personal effects were disinfected. No cases of illness of a suspicious character were encountered among them.

The examination of the members of a crew is certainly advantageous, for that, among other things, the detection of a case of Plague would lead to the thorough examination of a ship for dead rats. All crews were examined before departure of their ship, but no suspicious illness discovered in this way. The successful prevention of access of land rats to ships is a very difficult problem, and most of the devices recommended for that purpose are unreliable. Discs and perforated plates affixed to cables and hawsers are very liable to displacement, and when displaced offer no hindrance to the passage of vermin. The best plan appeared to be to order the use of some feet of barred parcelling wrapped around hawsers, etc., and that a man should be stationed after sunset at the gangway, which should be raised at night. This was ordered, but continual difficulty was experienced in inducing shipmasters to appreciate the necessity, and to pay adequate attention to detail. So much was this the case, that in several instances an endorsement was entered on the Bill of Health, to the effect that the precautionary measures directed, to prevent rats gaining entry to the vessel, had been neglected. The best security is in the clearing of ships of rats, before departure, by fumigation with irrespirable gases. Owing to the lack of any apparatus for the purpose this could not be done, but if in the future need should arise, fumigation with sulphurous gases will be carried out, an apparatus for the purpose having been fitted up.

These measures were discontinued when it became evident that there were no infected vermin in the shipping area.

There is very little export trade from Natal, and the articles exported are not such as would be likely to convey infection.

For the prevention of conveyance by land (1) and (2) infected individuals and fomites. Anything like a quarantine cordon, excepting around very small places, is admittedly impracticable. Though the majority of Natives who, after leaving Durban, were found sick or dead of Plague were actually ill on departure, and their illness could have been detected by careful medical examination at that time, yet it is practically certain that the knowledge that they would be examined would have induced them to proceed, or attempt to proceed, by road, as was done in some cases. Such a measure would also have given rise to an ineradicable belief that they would be presently prevented from leaving at all, and so probably have led many to depart at once.

The course adopted was to watch arrivals at villages and towns out of the range of ordinary daily communication with Durban on the railway to prevent them from delaying there, on their way elsewhere ; to detain any who appeared to be sick, for examination ; and to keep persons who had business in the place under observation.

In two instances only were persons who remained in a town or village attacked shortly after their arrival, and in another instance two boys were taken sick a few days after the return of one from Durban. There was no extension from these cases. All others attacked outside the boroughs were either discovered in their own homes in the country or suburbs, or on the way thither.

It was considered that Natives arriving by road at their kraals and there developing the disease would not, certainly in most instances, give rise to the disease in others, and that, if such a consequence should ensue, any outbreak would be easily controlled, and would not be likely at all to spread to other kraals, there being some space of open country between. In any case, although departure by rail might have been pre-

vented, departure by road could not be effectually controlled.

Natives are under general orders to report new or strange diseases, and information was readily obtained of the occurrence of cases. In both respects anticipation was realised, two cases only being followed by others, and adjoining kraals in both instances escaping.

In respect of persons leaving the Colony by rail, Natives proceeding to Johannesburg for work for the most part go direct from their kraals, a few perhaps remaining in Durban a few hours *en route*, but the numbers exposed to any chance of infection would not be great. Natives from other territories working in Natal travel most of their way home by road, and any infected persons would probably be overtaken by sickness before arriving at the border. Any system for securing examination of such persons or disinfection of their effects before they left would, in the absence of a cordon, be useless. The pathways at the border are too numerous to guard.

No special measures were therefore taken in regard to travellers by rail or road. No report was at any time received of any such persons being attacked.

(3) and (4) Precautions against conveyance of infection by agency of infected rats, grain, etc. There can be no question of the danger which presents of Plague being conveyed in "produce." It has been suggested that all granaries should be subjected to gaseous disinfection at frequent intervals, but many of the buildings used for this purpose in Natal cannot be effectively closed for such a purpose. At one time an attempt was made to deal with produce in small stacks by covering with tarpaulins and burning Alformant lamps beneath, but it was found that the resulting gas was not sufficiently confined to be effective. In any

case, experiments described in Part II., Appendix B, show the ordinary gaseous disinfectants to be ineffective for the purpose, and rats are frequently found in crates of straw packing, without there being any external evidence of their presence, and they are found alive in the necks of sacks of flour and grain after a considerable handling. The infection may also, as shown in Part II., adhere to bags, forage, hay, etc., apart from the presence of dead vermin.

As to what steps can be taken to prevent extension by this means is a most difficult question. Most of these articles cannot be effectually and reliably disinfected before being loaded in trucks without a practical certainty of damage to contents. Inspection, no matter how careful, will not be successful in distinguishing all bags and bales which have been worked by rats, and destruction of all which show traces thereof will be very costly, over an extended period of time, and even that would be an incomplete precaution.

The only measure which offers real security is that granaries, produce stores, and the like, shall be so constructed that rats cannot gain at any rate free access. This is more difficult than at first appears. Rats exhibit great capacity for climbing, ascending even perpendicular walls in the corners, and for squeezing their bodies through minute openings. The exclusion of mice may be accepted as impossible.

It is, above all, necessary that the use of wood and iron buildings for the storage of produce should be abolished, and that floors should be constructed of impermeable material. If doors are made to fit closely, and keen attention paid to netting with wire all windows, ventilators, and other openings, vermin do not gain free entrance and egress. The numbers in any store will thus be much diminished, and if the contents be neatly

stacked in such a way as to facilitate periodical clearance, there will be little opportunity for breeding. This offers far the highest degree of security both for the protection of the town itself and of its neighbours. The possibility of destroying all vermin in a store by the generation of irrespirable gas has yet to be proved as a practical measure, owing to the difficulty of effectual sealing, although the value in a ship's hold which can be closed is well established.

During the time of prevalence of rat Plague in the wharf area all "susceptible" matter was inspected in a general manner before removal was permitted, and where there was much evidence of its being infested by rats, the portions most attacked were destroyed. All stores were inspected frequently, and, when Plague-infected rats were discovered, were disinfected.

It appears that on two occasions infection was conveyed by such matters from Durban and communicated to rats elsewhere in the Colony, but whether by infected animals, direct or not, there is no evidence.

The entire contents of one large produce store (among the persons employed in which 15 cases occurred) and of two smaller were destroyed, the latter by fire *in situ*; one large stack of Lucerne hay, which had been lying at the wharves for several months, and several smaller quantities of grain, flour, hay, and the like, were also destroyed.

APPENDICES TO PART I.

CHART I.

SHEWING THE WEEKLY INCIDENCE OF CASES AND DEATHS AMONG PERSONS INFECTED IN DURBAN.
WITH MEAN TEMPERATURE AND RAINFALL.



CHART II.

SHEWING THE WEEKLY INCIDENCE OF CASES AND DEATHS AMONG PERSONS INFECTED IN DURBAN
AND ON DIFFERENT RACES SEPARATELY.



APPENDIX I.

Tables A to J, showing particulars in respect to groups of cases referred to in Part I.

Tables K and L, showing particulars as to race, age, sex, and fatality among cases dealt with in Durban Borough.

TABLE A.

Showing Place of Residence of 221 Cases of Plague.

<i>Group.</i>	<i>Resident at time of contracting Disease.</i>	<i>No. of Cases.</i>
<i>a</i>	Durban Borough and found there	163
<i>b</i>	Durban Borough and found elsewhere	23
<i>c</i>	Suburbs of Durban	13
<i>d</i>	Country (European Village 1, kraals 11)	12
<i>e</i>	Suburbs of Maritzburg	1
<i>f</i>	Borough of Maritzburg	9*
		221

* 11 were shown in weekly returns, but 2 of these were subsequently proved not to be suffering from Plague.—*Vide* Part II.

TABLE B.

Showing Particulars of 49 Cases in (b), (c), (d), (e), Table A.

PRIMARY CASES.							SECONDARY CASES.	
Date of Departure from Durban by Road or Rail.	Discovered.		At places where dis- covered.		Isolated.		Number.	
	Suburbs.	Country.	Found dead or died later.	Re- cov- ered.	Died.	Recov- ered.		
.. .. .	Dec. 24	..	I	..	..	..	..	..
January 9 ..	..	Jan. 11	I	..	..	..	..	..
January 20 ..	..	Jan. 23	I	..	..	..	..	..
January 20 ..	..	Jan. 23	I*	..	..	..	4 (1 recovered)	..
January 20 ..	..	Jan. 25	I	..	..	..	..	..
January 20 ..	..	Jan. 22	..	I	..	..	..	..
January 20 ..	..	Jan. 23	..	I	..	..	..	..
January 20 ..	..	Jan. 26	I	..	..	..	..	..
January 24 ..	..	Jan. 24	I	..	..	..	..	..
February 4 ..	..	Feb. 6	I	..	..	..	..	..
February 7 ..	..	Feb. 10	I	..	..	..	..	..
February 8 ..	..	Feb. 9	..	I	..	..	..	..
February 12 ..	..	Feb. 12	I	..	..	..	..	..
.. .. .	Feb. 11	..	..	..	I	..	..	..
.. .. .	Feb. 17	..	..	..	..	I	..	..
February 19 ..	..	Feb. 19	..	..	I	..	..	..
February 17 ..	..	Feb. 21	..	..	..	I	..	..
.. .. .	Feb. 21	..	..	..	..	I	..	..
February 25 ..	..	Feb. 26	..	..	I	..	..	..
.. .. .	Mar. 5	..	I	..	..	..	..	..
.. .. .	Mar. 13†	..	I	..	..	..	..	..
March 13 ..	..	Mar. 16	I	..	..	..	..	..
March 18 ..	..	Mar. 23	..	..	..	I	..	..
.. .. .	Mar. 16	..	I	..	..	..	..	..
.. .. .	Mar. 19	..	..	..	..	I	..	..
March 19 ..	..	Mar. 19	..	..	..	I	..	..
March 17 ..	..	Mar. 25	..	..	I	..	..	..
.. .. .	Mar. 22	..	..	..	..	I	..	..
April 6 ..	..	April 6	I	..	..	..	..	..
.. .. .	April 20	..	I	..	..	..	..	..
April 2 ..	..	April 8	I‡	..	..	..	7 (all died)	..
Not known ..	..	May 8	I	..	..	..	..	..
May 6 ..	..	May 11	..	..	I	..	..	..
.. .. .	May 13	..	I	..	..	..	..	..
.. .. .	May 17	..	I	..	..	..	..	..
.. .. .	May 19	..	I	..	..	..	..	..
May 23 ..	..	May 25	I	..	..	..	..	..
.. .. .	July 7	..	..	..	I	..	..	..
14			24	22	3	6	7	11
38			38			11 = 49		

Those on which date of departure not marked went to and from town, mostly daily.

* It is possible that this was a pneumonic case, but there is no clear account of the symptoms available.

† Maritzburg.

‡ Acute sthenic pneumonic type.

TABLE C.

Showing Details of Cases in Table B.

<i>Recovered—</i>				
All Bubonic { Primary 10				
Died— Secondary 1 11				
Primary 28				
Secondary 10 38				
49				

<i>Primary Cases on which Necropsy was held.</i>					
				<i>Pneumonia.</i>	<i>Confirmed by Bacterio- scopic examination and in some cultivation.</i>
Bubonic	..	..	7	0	4
No bubo	..	..	12	5	7
Not specified	..	..	2	0	2
21				5*	13

* In 3 pleurisy also.

<i>Total Cases on which no Necropsy was Held.</i>				
		<i>Bubo.</i>	<i>Pneumonia. No Bubo.</i>	<i>Total</i>
Primary	..	4	3	7
Secondary	..	2	8	10
		6	11†	17

† 5 seen during life: 6 diagnosed from descriptions of friends of deceased that they had suffered from cough, pain in chest and difficulty in breathing, and that the sputum was blood-stained. All 6 died after illness of two to three days in ones and twos in rapid succession after arrival from Durban of a man who was taken ill with like symptoms two or three days after arrival.

TABLE F.
Showing Particulars of 63 Cases Occurring in 16 Tenements in Durban Borough.

Dwell- ing.	Dates of Occurrence of Cases.	Description of Building.	Nationality of Cases.	Remarks.
A	March 13, March 18, March 23 * † ..	Brick store	Natives	Infected with rat plague.
B	January 9 † (1 case), 17 (38 cases), 20 (4 cases), 22, 24 (6 cases) * † ‡ ..	Brick store	14 Natives	Infected with rat plague. { Three distinct rooms, separate outside entries.
C	¶ February 28, March 8, May 29 ..	Wood and iron	Indians	Infected with rat plague.
D	January 17, January 18, May 4 (2 cases)	Wood and iron	1 Indian 3 natives	1 Sick on admission to In- dian Immigration Depot.
E	April 24, April 27, May 1 ..	Wood and iron	Indians	Infected with rat plague.
F	December 24, January 9, 12 ¹ , 16, 28, 31 ..	Wood and iron	Indians	Infected with rat plague.
G	January 3, January 17 ..	Wood and iron	Indians	Infected with rat plague.
H	January 5 (2 cases) ..	Wood and iron	Natives	
I	January 27, March 16 ..	Wood and iron	Indians	
J	February 3, March 1 ..	Brick	Europeans	
K	February 6, † ² February 8 (3 cases); Febru- ary 8 or 9 † ..	Wood and iron	Indians	
L	May 27 (2 cases), June 1 (1 case) ..	Wood and iron	Natives	
M	May 8 (2 cases) ..	Ship	Indians	
N	March 17, March 19, March 21, March 22 ..	Wood and iron	Natives	
O	¶ March 16, March 30 (2 cases), April 4 (2 cases) ..	Wood and iron	Indians	Three distinct rooms, sep- arate outside entries.
P	¶ March 18, April 8 (2 cases) ..	Wood and iron	Indians	Two distinct rooms, sep- arate outside entries.

* Ill some days.
† Discovered outside Durban.
‡ in a kraal from infection emanating from one of these
till late.

¶ Separate rooms, distinct entries.

† Discovered on February 21, having been away in suburbs.
‡ These are taken as the primary group, full information of the first not being received

|| 4 cases resulted

TABLE H.

(Collated from Tables B, D, G).

Showing Relation of Primary Cases or Groups of Cases and Secondary Cases.

Group Letter in Table A.	Total Cases.	Potential centres of Infection.	Possibly operative.	Number of cases within 10 days in same tenement.	Percentage of Total cases.
a†	..	129	10	25	..
b
c
d	..	38	2	11	..
e
f	..	6	1	1	..
Totals	221	173	13	37	16.7

† Plus 7 from "B."

One, 2, or more cases of practically simultaneous onset are taken as a centre. The total cases for each group are not given separately, because it was necessary for 7 cases to be considered as secondary in "a" and primary in "b" as causally related to "d," and thus confusion in the totals would have arisen.

There were 6 cases in group "a," concerning which there is no information as to their associations, and in groups *b, c, d, e* in respect of 8 the antecedents *before attack* are unknown, beyond the fact that five worked in certain definite neighbourhoods.

TABLE J.
Showing Occupations of 221 Cases of Plague.

	Produce Stores.	Stablemen.	Sanitary work: General.	Sanitary work: Special.	Warehousemen.	Storemen.	Wharf Labourers.	Other Labourers.	Seamen.	Water Police.	Cooks.	Waiters.	Hawkers.	Traaers, Mohammedan.	Laundrymen.	House Servants.	Bakery.	Aerated Water Manufacturers.	Infants.	Women and Children.	Mortuary Attendant.	Miscellaneous.	Unknown.	Kraal Natives.	TOTAL.
European *	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	26
Indian	2	4	12	2	3	3	10	7	2	2	1	3	6	5	2	4	2	2	3	23	1	3	2	2	94
Native	25	14	2	2	2	4	12	11	2	2	2	2	1	2	1	7	1	2	2	2	2	5	5	11	101
	29†	20	12	4	5	7	22	20	3	2	1	3	7	5	1	11	1	2	4	25	1	18	7	11	221

* Includes other coloured races.

† 26 of these form part of the total in Table I., sect. i., with text.

It is somewhat remarkable that of the 29 persons working in produce stores, 26 worked in places from which rats examined were found to have died of Plague, whereas in none of the stables in which the twenty stablemen worked were infected rats discovered.

Rats generally visit stables to obtain food, but do not harbour in the stalls; but they make their nests

and establish themselves in produce stores among the sacks and bales. When dying in numbers of epizootic disease in the latter it is probable that their bodies in considerable numbers will be found or will attract attention when decomposition sets in. In stables, on the other hand, rats are not likely to die in large numbers, and any few which do die there may readily escape notice.

TABLE K.

Showing Race, Age, Sex, and Result in 174 Cases Dealt With at Durban.

Age Period.	Europeans.		Coloured.		Indian.		Natives.		Totals.	
	Male.		Female		Male.		Female		Male	Female.
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Under 5	.	.	.	.	.	.	3	3	.	.
5 to 10	.	.	.	.	1	1	.	.	2	1
10 to 15	.	.	.	.	1	1	2	1	3	1
15 to 20	1	.	2	1	.	.	.	.	12	8
20 to 25	4	1	.	.	2	2	.	.	13	12
25 to 30	7	2	.	.	1	1	.	.	20	15
30 to 40	4	1	.	.	.	.	.	.	3	2
40 to 50	1	.	.	.	1	1	.	.	6	5
50 to 60	.	.	.	.	.	.	.	.	7	6
Over 60	.	.	.	.	.	.	.	.	.	.
Totals	17	4	2	1	6	6	.	.	69	56

TABLE L.

Showing Percentage Fatality of Cases in Table K.

Nationality.	Age Periods.							
	SEX.	1-5	5-10	-20	-30	-40	-50	50-
European	Male	..	..	0%	27%	25%	0%	
	Female	..	..	50%	..	..	..
Coloured	Male	..	100%	100%	100%	..	100%	
	Female	..	..	..	..	..	..
Natives	Male	..	50%	60%	69%	86%	100%	
	Female	..	..	..	..	..	..
Indians	Male	..	100%	86%	82%	68%	100%	
	Female	100%	0%	80%	71%	83%	100%	
All Races	Male	..	89%	67%	70%	67%	86%	
	Female	100%	0%	71%	71%	83%	100%	
All cases		{ Males 71.47 Females 76.00 }		All cases 71.26.				

APPENDIX II.

Particulars of Cases apparently infected by fomites or food.

One group of two belonged to the crew of the steamship *Zingara*, which arrived from Madagascar on May 22nd. On May 23rd one of these men went ashore. The other two did not leave the ship. On May 27th the former and one of the latter were taken ill, and on June 1st the third. Thus, although the third case might have received infection from either of the others, the first two cases must have arisen from a common cause. No others on board were attacked, and no source of infection was discovered in the ship itself.

A child, aged 6 years, was admitted from the suburbs of Durban just beyond the Borough boundary, and died. Bacilli indistinguishable from those of Plague were found in the tonsil and cervical glands. A sister had previously been ill with "tonsillitis" and recovered; but in the light of the second case, it appears possible that the "tonsillitis" was caused by the Plague Bacillus. No source of infection could be discovered, and neither of the children had recently been in Durban.

Two boys employed in a racing stable in Maritzburg were attacked. One died, the other recovered; the former had been in Durban from May 30th to June 2nd, and was taken ill on June 13th; the latter had not left Maritzburg, and was taken ill on June 12th. The boys lived in the same room, and beneath the floor of the next a number of dead and putrid rats were found. Owing to the decomposition and the fact that they had been soaked in sheep dip for some hours, bacterioscopic examination was useless. No information was obtainable as to whether poison had been laid or not, but against the supposition of their having died of Plague is the fact that numbers of rats killed on the adjoining premises about that time and both before and after, were uninfected, and no Plague-infected rats were found there or elsewhere in Maritzburg after March 31st. The other cases probably infected by fomites were single cases stated not to have been in the town of Durban recently.

APPENDIX III.

Prominent instances of the connection between rat plague and human cases are found in the following :—

1. Grain and produce store in Commercial Road, Durban, thoroughly infested with rats, dozens of dead being found. Infected rats were examined first on January 7th. On the 9th 1 employé was taken ill after leaving Durban; on the 17th 4,* on the 20th 4 more, and between the 22nd and 24th 6 others were discovered in native kraals. The store was being cleaned up and disinfected when the cases occurred, on the 17th (the first case went away by rail, and the facts were not discovered till later), and it was then closed and the contents afterwards saturated with solution of perchloride of mercury and destroyed. The cases occurring on the 20th and later were working in the store on the 17th.

2. Railway locomotive workshop. Europeans were attacked on March 16th, 19th, and 22nd and April 2nd—at the latter part of March rats examined were found to be infected. The vermin used to frequent the shops in search of scraps of food, and 1 patient had found three dead in his locker in the workshop one morning.

3. “Magazine” Barracks of Corporation. These consist of several long buildings of corrugated iron, unlined, with boarded ceilings, and all except one having concrete or asphalt flooring. They are divided by single-boarded partitions into a number of rooms. Several hundreds of persons are accommodated in them. There is no place where rats could harbour except above the ceilings, and here they were found to be in large numbers, gaining access by climbing the verandah posts. One man was continuously employed at the barracks in the destruction of vermin. It was his practice to lay poison and set traps in the loft. In the course of his visits, he gathered together dead

* Includes 1 European not resident on the premises.

bodies, and those which were "fresh" he sent to the laboratory. One hundred and nine were so sent on forty-seven different occasions, and examined, and 8 of them found to be infected. Doubtless many of the others which were not "fresh" and so not sent, were also infected. These rats were found between April 9th and June 30th. Fourteen cases of Plague occurred in these barracks, each one, however, in a different room—7 before April 9th and 7 afterwards. It is somewhat curious that no two inmates of any one room were affected. It is not to be understood that no rats died on these premises before April 9th, but only that no report to that effect was made by the occupants and no specimens sent.

Of the opposite—*i.e.* rat Plague not associated with human plague—a striking instance is found in the case of the goods-shed at Malvern Station about 12 miles from Durban. This is a small iron shed with a flooring of sleepers laid on the soil. On June 30th dead rats were found and sent to the laboratory, and there ascertained to have died of Plague. Two days later the contents were removed, the flooring pulled up, and between 60 and 70 rats (some dead and some dying) were discovered, the latter being all killed, and no lively rats seen. All this was, through misunderstanding, carried out without any precaution, and yet for all that fortunately not one of the persons so engaged was attacked by the disease.

APPENDIX IV.

*Special Regulations made by the Governor in Council under the
Public Health Act, 1901.*

GOVERNMENT NOTICE No. 26, 1903.

THE following Order, made by His Excellency the Governor in Council on the 9th day of January, 1903, under the authority of the Public Health Act, 1901, relative to the Borough of Durban, is hereby published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

10th January, 1903.

ORDER IN COUNCIL.

In pursuance of the powers contained in Sections 30, 31, and 32 of the Public Health Act, 1901, and with reference to the Order of the Governor in Council published under Government Notice No. 379, bearing date 14th June, 1902, it is ordered by His Excellency the Governor in Council as follows :—

1. All Regulations made by the Governor in Council under the provisions of the said Act on and after this date, and until this Order shall be revoked shall, save so far as a contrary intention may appear, or as may be inconsistent with their language, apply to the Borough of Durban.

2. For the purpose of carrying out any such Regulations in the Borough of Durban, the Health Officer for the Colony may, in his discretion, delegate any powers and authority under such Regulations to such of the Borough authorities as he may consider proper, and he may make such other alterations in regard to the authorities named in the Regulations as he may consider necessary for the better execution thereof in the said Borough.

GOVERNMENT NOTICE No. 33, 1903.

THE following additional Regulation, made by His Excellency the Governor in Council, under the provisions of Section 25 of the Public Health Act, 1901, is hereby published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

10th January, 1903.

Additional Regulations under the Provisions of Section 25 of the Public Health Act, 1901.

In the Borough of Durban the owners of all stores in which are kept or stored any Grain, Bran, Flour or Meal, Forage, Fodder, Hay, or Straw, shall cause all runs or holes used by rats or mice to be firmly filled with cement, and shall cause the floors of such stores to be rendered, as far as possible, inaccessible to vermin.

GOVERNMENT NOTICE No. 38, 1903.

THE following Regulations made by His Excellency the Governor in Council, under the provisions of Section 25 of the Public Health Act, 1901, are hereby published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

10th January, 1903.

Regulations under the provisions of Section 25 of the Public Health Act, 1901.

1. All employers of coloured labour in Durban, or in any place in which the existence of Plague shall be subsequently proclaimed, shall take such steps each morning to ascertain whether any of their employés are absent from work.

2. In the event of any employé being so absent, the employer shall forthwith enquire and ascertain whether such absence is due to illness.

3. If the employé so absent shall be found to be ill, the employer shall immediately engage the services of a qualified Medical Practitioner to examine such person then, and each day subsequently, until he shall be restored to health. He shall obtain from such Medical Practitioner a certificate stating the nature of the illness from which such employé is suffering.

4. Such certificate shall state clearly if there is anything in the nature of the illness to arouse any suspicion of the disease being Bubonic Plague.

5. In the event of any such statement being endorsed on the certificate, the employer shall forthwith despatch the certificate to the Plague Administration Department at the Point, Durban, or elsewhere, as may be notified by advertisement in the daily Press, together with a clear description of the place where the person is residing or is to be found, with the name of the person in full.

6. It shall also be the duty of the employer in such case to make adequate provision against the possibility of a person so sick with suspicious symptoms leaving the place where he then is until he shall have been examined by a Medical Officer from the Plague Administration Department.

7. All employers hereinbefore referred to shall keep proper records of the persons in their employ, and of cases of absence and of sickness amongst them, which records, as well as all medical certificates granted under the foregoing regulations, shall at all times be open to inspection by any officer duly appointed by the Plague Administration Department.

8. Any person who shall harbour or conceal, or assist to conceal, any person suffering from any illness, sickness, or disease shall be deemed to be guilty of an offence.

9. Any person who shall fail to give information to any Medical or other Officer or Official appointed by the Health Officer for the Colony, or by any Corporation, in answer to inquiries about the existence of any case or cases of illness, shall be deemed guilty of an offence.

GOVERNMENT NOTICE No. 39, 1903.

THE following Regulations, made by His Excellency the Governor in Council, under the provisions of Section 8 of the Public Health Act, 1901, are hereby published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

10th January, 1903.

Regulations under the provisions of Section 8, Public Health Act, 1901.

1. From and after the date hereof, and until the same shall have been cancelled, no grain, bran, flour or meal, forage, fodder, hay, straw, or open crates containing straw or other packing material, all or any of which may now or hereafter be stacked or stored within the area of the Point District, Durban, anywhere South of West Street, or within any other area which may be subsequently proclaimed by the Health Officer for the Colony, shall be removed from such area or handled in any way without the written consent of the Health Officer for the Colony, or of an officer duly authorised by him, and subject to such conditions as may be set forth in such consent. Any person desiring to remove or handle such goods, material, or articles hereinbefore mentioned, shall make application for such consent in writing, at the Plague Administration Office, Point, or at such other place or places as may hereafter be appointed for that purpose, at least 48 hours before the time at which it is desired to effect the removal or to handle the same.

2. The Health Officer for the Colony, and any Medical Officer appointed by him or by the Corporation of Durban, is hereby authorised and empowered to stop the removal or handling of any goods, articles, or materials which, in his opinion, are likely to convey infection, whether such goods, articles, or materials are stacked or stored in any store, warehouse, shed, or other building, or in the open. The order prohibiting such removal or handling shall be served on the owner or person under whose care or control such goods, etc., may be, and any person removing or handling, or in any way attempting to remove or

handle, such goods, etc., after such order shall have been so served shall be liable to the penalties provided by the Public Health Act, 1901.

3. It shall be lawful for the Health Officer for the Colony, and he is hereby authorised, whenever he shall think fit so to do, to order the whole or any part of such goods, etc., the removal or handling of which shall have been prohibited, to be destroyed or dealt with in such manner as he may deem necessary, and the owner shall cause such instructions so given to be carried out. The owner of any goods so destroyed or dealt with shall be entitled to compensation, subject to the terms and provisions of the Public Health Act, 1901.

GOVERNMENT NOTICE No. 89, 1903.

PUBLIC HEALTH ACT.

THE following regulations, made by the Governor in Council under the provisions of Sections 24 and 25 of the Public Health Act, 1901, are published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

5th February, 1903.

Regulations under Sections 24 and 25 of the Public Health Act, 1901.

1. These Regulations shall, until extended by order of the Governor in Council, apply only to the Borough of Durban.

Regulations under Section 24.

1. The Health Officer for the Colony, or the Medical Officer of the Borough, shall have power to order the removal to hospital of any person found to be suffering, or suspected of suffering from Bubonic Plague.

2. All persons employed by or under the authority of the Health Officer for the Colony to carry out such removals shall for all purposes connected therewith have authority as constables. If the execution of an order is resisted, such force may be employed as is necessary, and any person may be called upon to assist in the enforcement of the order.

3. Persons so removed to hospital shall be detained until

discharged by order of the Medical Officer in charge, and during their stay they shall conduct themselves in accordance with the instructions of such Medical Officer.

4. The Health Officer for the Colony, or any Medical Officer appointed by him, and the Medical Officer of Health for the Borough, shall have power, if circumstances appear to him to warrant such action, to order the removal to any place appointed therefor of any persons who may have been exposed to infection, either by living in the same room or house with any person affected with Bubonic Plague, or by visiting any such person, or by entering any such house or building, or on account of unusual mortality among rats or mice or other small animals in or around the house or building in which the aforesaid persons live or to which they resort. The enforcement of this clause shall be subject to the terms of any resolution of the Committee hereinafter provided for.

Regulations under Section 25.

1. The bodies of all persons dying in the Plague Hospital shall be disposed of in such manner and in such place or places as may be deemed most suitable by such Committee as aforesaid, or in case of emergency by the Health Officer for the Colony, or other Medical Officer acting on his behalf.

In the case of persons dying of Bubonic Plague elsewhere than in Hospital, it shall be competent for the said Committee, or the Health Officer for the Colony, or Medical Officer acting on his behalf, if deemed by them or by him desirable, to order that all bodies, or any particular body, be disposed of in such manner and in such place or places as they or he may consider suitable and convenient.

2. The Health Officer for the Colony, or the Medical Officer of Health for the Borough, shall have the power to order that any particular house or building which may be a source of danger, either from a case of the disease Bubonic Plague having occurred therein, or on account of unusual mortality among rats, mice, or other small animals in or about such house or building, shall be closed, and not re-occupied or re-entered by any person until so ordered by the like authority.

3. The Health Officer for the Colony, or the Medical Officer of Health for the Borough, shall have power to order the demolition of any shed, hut, privy, or the like, and the destruction or removal of the materials thereof, and the destruction of any shed or shanty.

4. If it shall appear to the Committee that the condition of any house or building of permanent and substantial structure is such that danger of spread of infection is likely to result therefrom, and that on this account it is necessary that it should be demolished and removed, or that structural alterations be made therein, the Committee shall make a report thereof to the Health Officer for the Colony, who, if satisfied upon inquiry as to the circumstances, may make a written recommendation thereupon to the Minister (the Colonial Secretary).

If, upon such recommendation, the Minister shall sign an order on behalf of the Government for such demolition, removal, or alteration, the Health Officer for the Colony shall inform the Committee accordingly, and the latter shall be empowered to carry out the order by any persons whom they may employ for that purpose.

The Committee shall have power, where necessary, to order and enforce the removal of inmates prior to alteration or demolition.

Committees.

1. For the purposes of these Regulations, and of otherwise assisting in the administration of the Act, the Governor may from time to time appoint one or more Committees, and make or revoke any such appointment, or the appointment of any members.

2. The District within which each such Committee shall exercise authority, together with the number and names of the persons of which such Committee is to consist, and of the Chairman, and of the number required to form a quorum, shall be published in the *Government Gazette*.

3. The Governor may also from time to time appoint a secretary of any such Committee.

4. Unless urgency prevents, timely notice shall be given to each member of a Committee of any sitting.

5. If at any sitting the Chairman of the Committee be absent the members present may elect a Chairman for the occasion. The decision of the majority shall be the decision of the Committee. The Chairman shall have a deliberative vote, and, in the event of an equality of votes, a casting vote also.

GOVERNMENT NOTICE NO. 148, 1903.

THE following additional Regulations made by His Excellency the Governor in Council under the provisions of Section 25 of the Public Health Act, 1901, are published for general information.

C. BIRD,

Principal Under Secretary.

Colonial Secretary's Office, Natal,

21st February, 1903.

Regulation under Section 25 of the Public Health Act, 1901.

If it shall appear to the Committee that any house or building is, owing to its condition or that of the neighbourhood, or to the conditions of its occupation, or for any other reason, likely to be a source of danger, or to favour the spread of infectious disease, it shall be competent for the Committee to direct that such house or building shall be closed and the inmates removed therefrom until such time as the Health Officer for the Colony or the Medical Officer of Health for the Borough shall advise that it may with safety be reoccupied.

Additional Regulation under Section 25 of the Public Health Act, 1901.

In any place to which this regulation applies, the owners of all stores in which are kept or stored any Grain, Bran, Flour or Meal, Forage, Fodder, Hay or Straw, shall cause all runs or holes used by rats or mice to be firmly filled with cement, and shall cause the floors of such stores to be rendered, as far as possible, inaccessible to vermin.

This regulation shall apply to the boroughs of Newcastle, Ladysmith and Dundee, the townships of Verulam and Greytown, and the villages of Estcourt, Howick, Stanger and Richmond.

Part II.—Bacteriological and Experimental.

THE LABORATORY, MARITZBURG.

January 19th, 1903.

TO THE HEALTH OFFICER FOR THE COLONY.

SIR,—

As the general details of the recent epidemic have been dealt with fully elsewhere, the subjoined report is intended to be restricted simply to details appertaining to the bacteriology proper of the outbreak without more than a passing reference where necessary to such points of clinical and epidemiological interest as seem directly connected with the matter under consideration.

One item, however, of bacteriological as well as general interest in connection with the history of the outbreak which seems in place here is the undoubted value of precautionary measures for prompt bacteriological action which were assured before the advent of the disease. The establishment of a small laboratory for the routine examination of rats found dead or sick in the neighbourhood in which it was considered the chief danger of introduction lay was attended by the best results, and it is probable that the certainty with which the commencement of the epizootic was detected through this means rendered possible that prompt detection and suppression of those earlier cases of the disease so important in combating an epidemic of Plague.

I propose, therefore, in the present Report to con-

fine my observations to such points of bacteriological interest in connection with the *Bacillus Pestis Bubonicæ* as its morphology, vitality, and virulence, and to amplify these points with clinical or other evidence only where such seems necessary.

The pressing demands made upon my time in my official capacity as the Director of the Research Laboratory, Maritzburg, made it imperative to ask for assistance in a work which it was hoped would embrace a broad field of inquiry. The necessity for such provision was readily concurred in, and accordingly the assistance of Dr. Haydon, who had previously been engaged by the Government of Bombay in connection with Plague work, was secured, and he assumed duty on December 18th, within a few weeks of the outbreak, and at once undertook the routine duties of the small Laboratory established at the Point, Durban.

Those duties—which, though routine, were none the less onerous and responsible—consisted chiefly in the examination of the rodents found dead or dying in various localities, and as the arrangements for detection and collection of rats were of an ample and efficient nature, it became necessary daily to subject the organs and tissues of a large number of rats to bacterioscopic examination. This, together with the constant observation and maintenance of cultures of organisms (made during life or from the cadaver both of man and the rat) in cases where the clinical history required confirmation or support, necessitated constant and assiduous application.

With the extension of the epidemic to Pietermaritzburg, and the possibility of making other provisions for carrying on the routine work, I thought it advisable to utilise the services of Dr. Haydon at Pietermaritzburg upon work of a less routine nature, and

this suggestion meeting with your concurrence, he was accordingly transferred to my Laboratory from Durban.

In the subjoined report, therefore, I have had the assistance of Dr. Haydon, who has worked with me with untiring assiduity for the past ten months, and to whom I am indebted for many suggestions and a hearty co-operation.

One of the earliest difficulties encountered in the bacteriology of the Natal outbreak was that of arriving at an exact diagnosis from the microscopical appearances available.

This point (which, as will be readily recognised, is one of prime importance where prompt repressive steps are necessary) does not seem to have been recorded in the history of outbreaks of the disease elsewhere, with the exception, perhaps, of the recent epidemic in the Cape Colony.

The difficulty, however, in Natal has occurred upon quite a number of occasions in both human and animal tissues, and has shown beyond dispute the unreliability of the usual simple microscopic procedure in deciding upon a case of suspected Plague.

It has been a matter of repeated observation that organisms isolated from various cases, other than Plague, submitted for bacteriological opinion have appeared identical with the *Bacillus Pestis Bubonicæ* as regards size, shape, and the different staining property possessed by this organism. This difficulty arising in connection with the accurate and prompt diagnosis of the disease has been dealt with in the following pages, as it is felt that the reliance which it has been customary to place generally upon bacterioscopic appearances in the diagnosis of Bubonic Plague, apart from those derived directly from bubo-juice, etc., cannot for the future be given full weight, except where supported by

a clinical history of the most unequivocal nature, tending to confirm the indications of the microscope.

The validity of this objection to placing full reliance upon the bacterioscopic appearances will appear from an inspection of the photomicrographs which elucidate this point, from which it will be seen that close similarity may exist on comparison with the typical or text-book bacillus of Kitasato, and other alien organisms of similar morphology.

That this difficulty of diagnosis should have been one of not infrequent recurrence seems more remarkable when the limited number of classified organisms capable of being mistaken microscopically for the Plague bacillus is considered.

The liability of confusing the *Bacillus Pestis* with other organisms than those hitherto recognised as possible causes of confusion—such as the germs of Chicken Cholera, Rabbit Septicæmia, Swine Plague, Pneumo-pleurisy of Calves, etc.—must be considered, therefore, as increasing the limitations attending the use of the microscope alone.

I propose to deal briefly in the first place with the normal, cultural, and microscopical appearances met with in the Plague Bacillus during the Natal outbreak. Such observations can have in most instances the value of merely corroboratory evidence, though it is hoped that some of the details in this connection (hitherto undescribed) may prove of value to subsequent workers in the same field.

After dealing with the morphology of the organism, I propose to discuss the important question of its vitality and virulence under varying conditions of environment, and lastly its pathogenicity for the lower animals.

Finally, I shall hope to illustrate briefly the difficulties

sometimes encountered in arriving at a definite diagnosis for clinical purposes, etc., by quoting details of some of the instances in point and their differential features.

It has been thought advisable to illustrate the text as amply as possible.

Apart from the many curious instances of pleomorphism exhibited by the bacillus, simulating the morphology of almost all forms of bacterial life, I have thought it advisable to bring forward evidence as conclusive as might be of the typical nature of the organisms used in the endeavour to produce the disease in pigs, fowls, etc. The magnification of all photomicrographs is constant throughout—viz. 950 diameters.

I have the honor to be, Sir,

Your obedient Servant,

H. WATKINS-PITCHFORD, F.R.C.V.S.

(*Government Bacteriologist*).

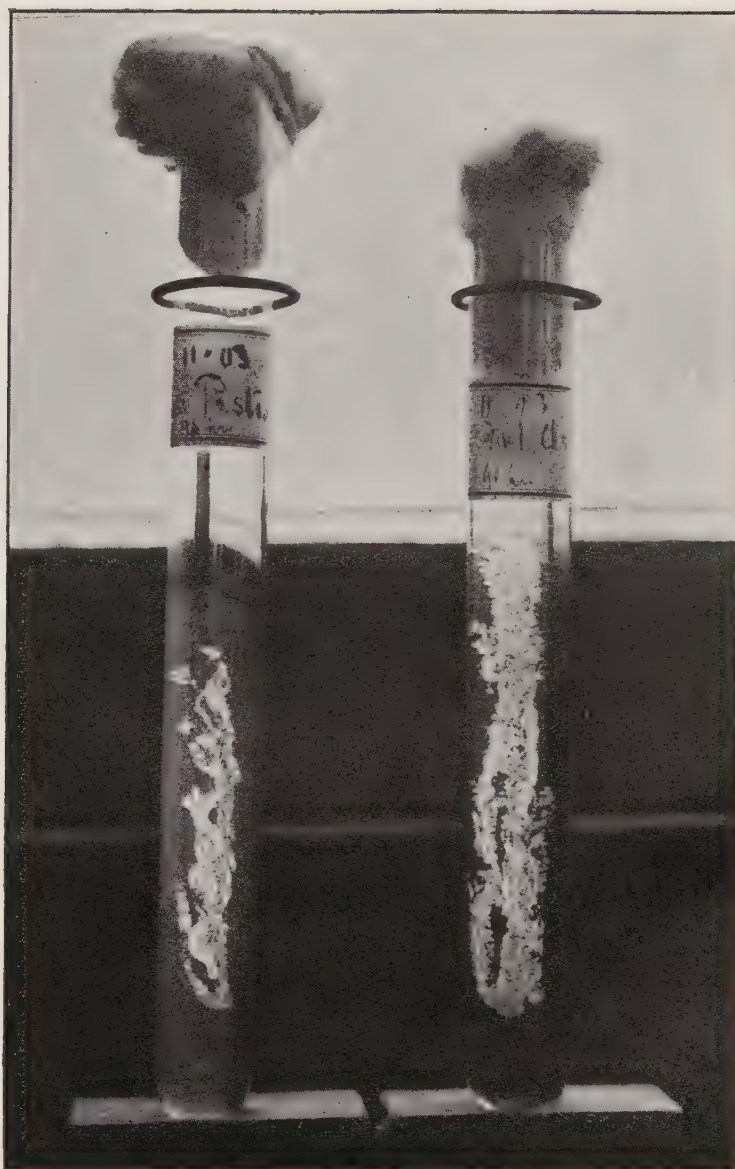
SECTION II.

OPTIMUM CONDITIONS OF TEMPERATURE,
AND
CULTURAL OBSERVATIONS.

OPTIMUM CONDITIONS OF TEMPERATURE.

A SERIES of observations undertaken with the object of determining the above point has shown, while the growth is perhaps slightly more vigorous and pronounced in the warm incubator at 37° C. during the first 48 hours, that after this period the tubes maintained at normal and subnormal temperatures rapidly outstrip those grown at 37° C. This is very noticeable after the expiration of one month, when it will be noticed that the tubes maintained at from 15° to 18° C. show evidences of much more copious and vigorous growth than those grown either at 20° or 37° C., while the difference between the growths from hot and cold incubators is still more marked. This point bears out the evidences of rapid degeneration noticed in the morphology of organisms cultivated at 37° C. for 10 days before being taken from the incubator.

The above observation is not without its significance in considering the seasonal influences connected with the spread of Plague epidemics, as the ability of the *Bacillus Pestis* to grow vigorously between so wide a range of temperatures as that existing between 15° and 40° C. would seem to show the ease with which this organism can adapt itself to the varying seasonal temperature.



a

b

FIG. 1.

Face p. 93.

CULTURAL OBSERVATIONS.

The growth even in early cultures presents varying appearances according to the amount of material sown, whether taken from tissues or from another culture, and the temperature at which cultivation is made. Thus with spleen pulp containing large numbers of the organisms the resulting growth on solid media will be a transparent slimy streak (*vide* Photo No. 2*d*), while if heart blood or a bouillon culture be used the early appearances will consist of discrete dew-drop-like colonies (*vide* Photo No. 1*a*).

In all the following observations a recent bouillon culture from a rat's spleen was used.

On *agar agar*, incubated at 37° C. for 24 hours, the growth can often be seen of a fairly granular character by the naked eye, and can always be detected by the use of a hand lens.

In 48 hours, at 37° C., growth is always apparent, and consists of minute discrete colonies, colorless, or of a delicate grey color, well raised above the surface of the medium.

These vary in diameter from .25 μ to 2 μ . By transmitted light, these minute droplet colonies, viewed with a lens, display a translucent opalescence.

After 72 hours the discrete appearance of the colonies tends rapidly to be lost by confluence, so that a 7 to 9 days' culture presents an irregular whitish growth, tending in its gradual coalescence to opacity, but presenting always well-elevated edges. Variations from the normal cultural type, such as described by Yersin, Klein, and others, have also been met with, and will be found on referring to paragraph 1, Appendix A.

Gelatine.—The growth upon nutrient gelatine is without any marked points of difference except such

as would result from the use of a medium of greater transparency (Fig. 1, *a*). Thus the discrete droplet colonies appear more translucent, and the opacity of their central parts less marked. No great differences in rapidity of growth subsist between this medium and agar agar. Where discrete colonies of any age exist the firmness of their attachment to this medium is noticeable, due probably to the depth to which the growth penetrates.

Glucose Agar.—Very similar to, but less abundant than on glycerine agar.

Litmus Agar.—Alkalinity commences to be observable in about 6 days.

Glycerine Agar (3 per cent. glycerine).—There are no very distinctive points between this medium and plain agar. Growth is less rapid, and has less color.

Salt Agar (2.5 per cent.).—The growth is somewhat less abundant than on other solid media, presenting no distinctive appearances.

In Rat Agar.—Growth was more abundant than on any other solid media used (see Fig. 2, rat agar *b* and *c* compared with plain agar *a* and *d*).

Rabbit Agar.—Little difference from plain agar.

On Ox Serum.—In 48 hours appears a thin opaque film, with a very finely granular surface which contrasts with the smooth iridescence of the rest of the slope. Touching with the öse makes little difference to the appearance of the film. As the age of the culture increases, little change takes place except that the film becomes thicker, more raised, and its surface becomes nodulated. On this medium a stickiness and toughness of the minute colonies are more often noticed than on other media. The growth on this medium is never so copious and abundant as on agar and glycerine

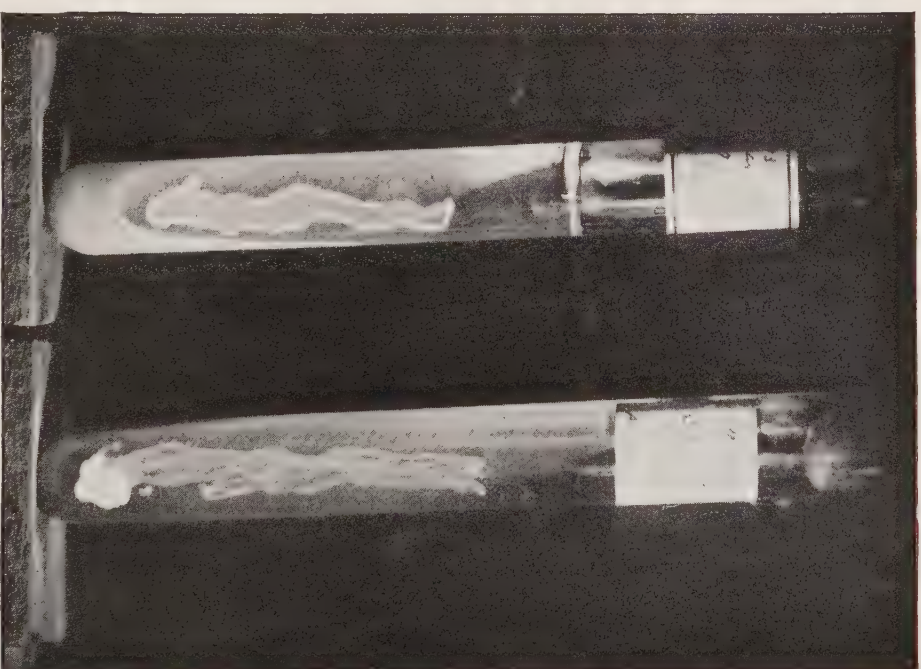
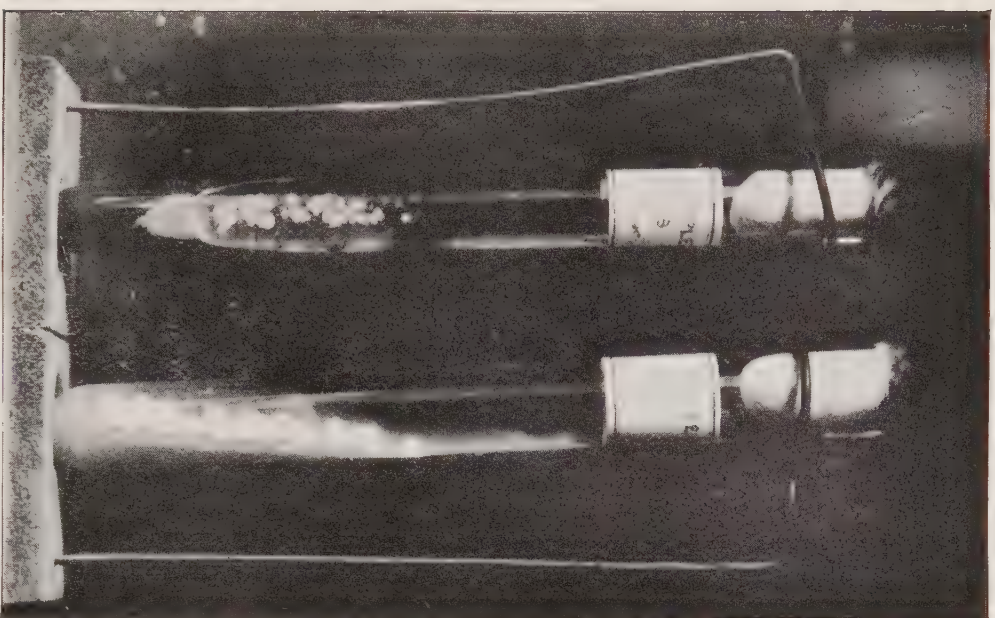


FIG. 2.

Care was taken to sow these tubes with equal quantities of material, and the growths are of equal size.

agar. This observation seems at variance with those of previous describers.

In Beef Bouillon.—At 48 hours a scanty deposit rises on agitation and faintly clouds the liquid—less viscid than in glycerine bouillon.

Tends to become more floccular as age of culture advances.

A film appears on the surface and adheres to the glass in about 72 hours.

Beef Bouillon (with glycerine 3 per cent.).—After the lapse of 24 hours a scanty, viscid, yellowish white whorl arises on agitation of tube.

Later flocculi are always to be found on the surface adhering to the sides of the tube.

If kept at rest after agitation the medium becomes clear again in 48 hours.

In *Glucose Bouillon* the growth is less abundant, but displays much the same characteristics as in plain bouillon.

Salt Bouillon (2.5 per cent. Na Cl).—Very little growth was obtained at any time. The medium at rest remains clear, but after a few days a faint cloudiness on agitation is noticed.

When sown profusely, however, in flasks in 5 per cent. salt bouillon-ghee, an abundant stalactitic formation is noticeable in 72 hours.

Rat Bouillon.—A more rapid and abundant growth is noticed than on beef bouillon, other characteristics being identical.

Milk.—Does not coagulate, and presents no particular characteristics.

Potato.—Growth slow, and without particular characteristics. After 20 days at normal temperature, the growth is dry, creamy-white, with irregular elevated edges (see Fig. 3).

Stalactitic Growth.—Much stress has justly been placed by previous observers on this cultural characteristic as a means of differentiation (*see* Fig. 4).

The best method of observing this interesting phenomenon would appear to be by sterilising small discs of cork, and when quite cold inoculating these fragments with a recent culture of Plague. These infected discs of cork are then transferred under aseptic precautions to flasks of ordinary bouillon or bouillon containing up to 3 per cent. salt. The appearances are to be noted best in an Erlemmeyer flask, the base of which, being considerably wider than the apex, allows detached fragments to fall clear to the bottom of the flask without risk of lodgment on the sides, with consequent obscuration of the interior of the flask. The formation of the growth which depends from the lower surfaces of the cork can then be readily observed, such growths being able, by reason of the buoyancy of the cork fragments, to attain to considerable dimensions before becoming detached and falling to the bottom of the flask. It is of interest to note that an infection of the flask with several organisms will not interfere with the production of this appearance beyond the general opacity or cloudiness of the medium, and this fact might possibly be of advantage as a point in the technique of diagnosis.

Before sowing such fragments of cork, after infection of the same, it is well to give the contents of the flask a gentle rotary motion, in order to prevent the adhesion of the cork to the sides of the vessel.

No special peculiarities are observable in the microscopical examination of portions of the stalactitic growth; oval or coccid forms are not so frequent as in many other media.

Anaërobiosis.—Growth appears to be almost in-

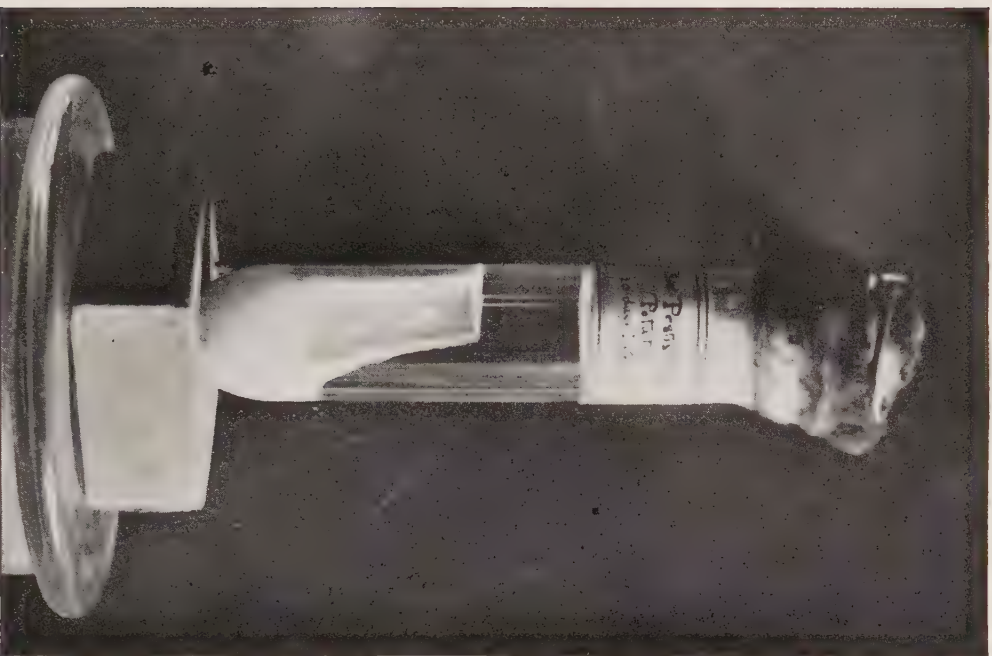


FIG. 3.

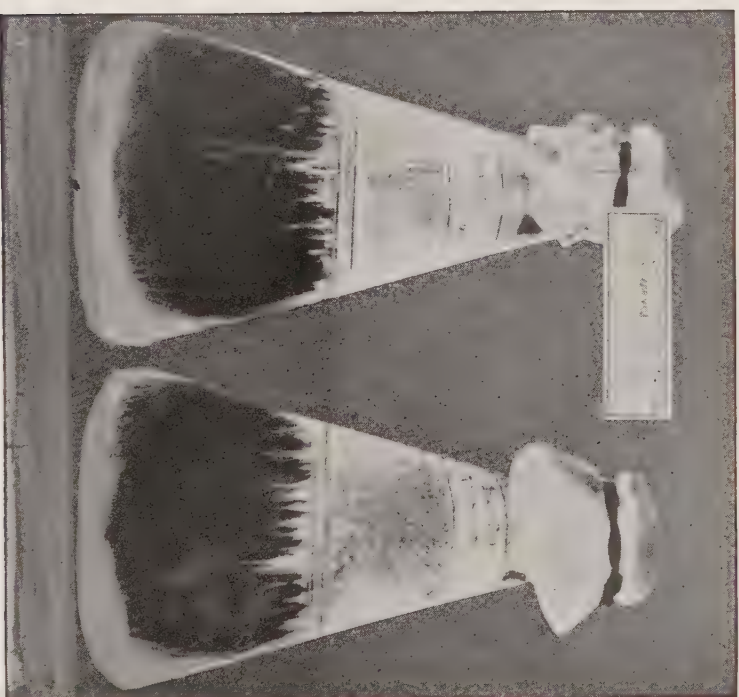


FIG. 4.



hibited in CO_2 . Bouillon shows no growth after a month. The statement that the vitality of the organism is increased when developing in earth, cow-dung, floors, etc., owing to the presence of excess of CO_2 in ground air, would not seem to be borne out.

The reaction of the organism is distinctly alkaline. After 36 hours' growth in neutral bouillon, this condition is marked and increases with age, being marked at eight months and beyond.

SECTION III.

MORPHOLOGY OF THE BACILLUS PESTIS BUBONICÆ.

THE organism, which may be looked upon as typical, is that to be isolated from the spleen, bubo, or blood stream. Its general description is well known—viz. that of a short ovoid bacillus staining more deeply at either pole. This characteristic of bipolarity can probably be produced in all bacillary forms of the true Plague organism by alteration in the technique of staining, and it will be further found that with the increase of age this characteristic tends to be lost. Although this bacillary form is to be looked upon as typical, it will generally be found that a large percentage of the organisms in any given preparation consists of coccal or spherical forms in which no bipolarity can be observed.

It may be noted here that considerable modifications in contour and differential staining properties appear to take place *in corpore* with advancing age of the bacillus and advent of putrefactive changes.

This observation is not without its value in examination of tissues of uncertain age, as it is probable that the typical form above alluded to tends to become less marked with the advance of time; and it should be borne in mind that these typical appearances cannot be certainly expected in tissues after a certain lapse of time.

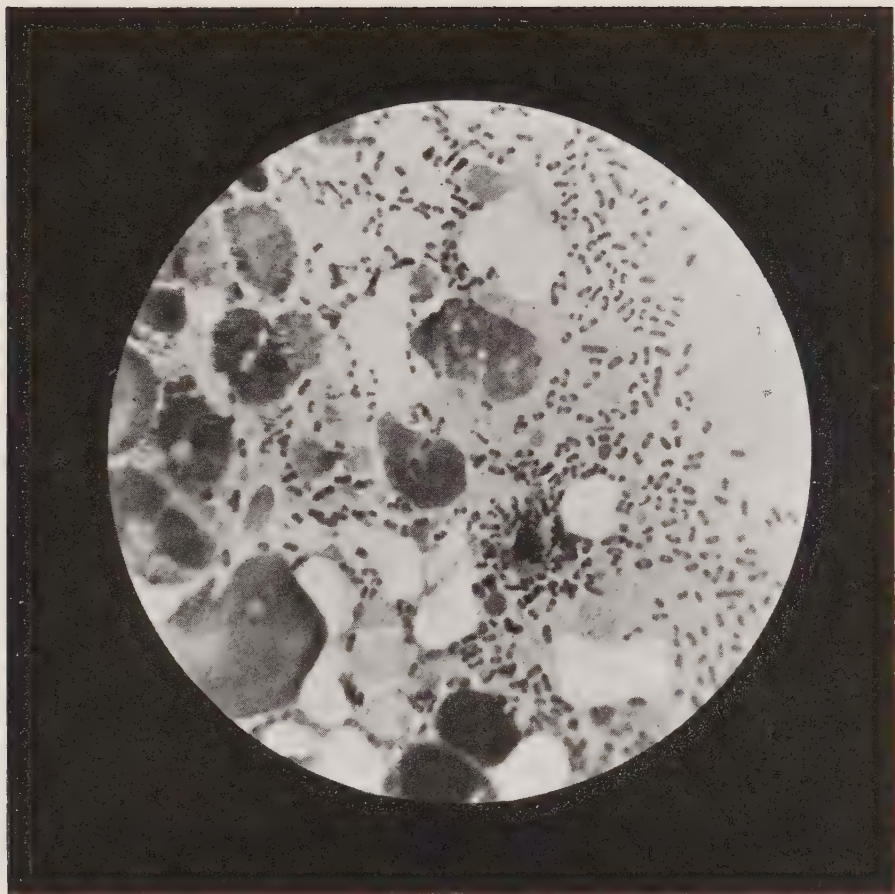


FIG. 29.

NORMAL TYPE OF BACILLUS IN THE RAT. *Face p. 98.*

This typical form of the organism will be found to obtain with constancy in the tissues of most of the animals to which it proves pathogenic. The only point of variance is a slight difference in measurement. The size of the *Bacillus Pestis Bubonicæ* taken from the human spleen has been found to average in length 1.64 microns, and in breadth $.82\mu$; while in the organism taken from the bubo itself the size is slightly smaller, averaging 1.448μ in length and $.82\mu$ in breadth. The above average was arrived at by 60 separate estimations, the extremes of length and breadth being respectively 3.4μ and 1.28μ .

Calculated from 120 estimations in spleen tissue taken from the rat, the organism gave a length of 1.584μ and a breadth of $.816\mu$, while in 50 estimations in guinea-pig tissue the length was found to be 1.311μ , and the breadth $.717\mu$, being thus of less size generally than that found in the human tissues. It may be stated, therefore, that the size of the *Bacillus Pestis Bubonicæ* in man and the lower animals averages about 1.5 microns in length by $.8\mu$ in breadth.

In cultures grown upon artificial media the microscopic appearances will be found to vary considerably. The various media used were as follows:—Agar, gelatine, glucose agar, litmus agar, glycerine agar, salt agar (NaCl 2.5 per cent.), rat agar, rabbit agar, ox serum, beef bouillon, beef bouillon with glycerine 3 per cent., glucose bouillon, salt bouillon 2.5 per cent., rat bouillon, milk, potato, etc.

On these media, although observations were commenced upon a 24 hours' growth in each case, it was decided to pass these over in consequence of the growth being so extremely slight that a risk was run of removing from the surface of the medium some of the organisms actually implanted there. The following

observations therefore are made upon growths 48 hours old and upwards.

(1) *Agar agar*.—After 48 hours' incubation the organism is seen as a short deeply staining bacillus varying in length from $\cdot62$ to $1\cdot7\mu$, the average of a number being $1\cdot066\mu$ and the average breadth $\cdot708\mu$. Practically no differential staining is observable, or only a slight trace.

After 72 hours at 37° C. on this medium the bacillus tends to lose its property of staining intensely, while some of the individual organisms have lost their rounded coccal forms, and tend in some cases to an irregular truncated or even cubical shape. This appearance tends to become more marked in 96 hours, and the failure to stain becomes more noticeable.

After 144 hours the tendency to irregularity of contour is marked, while a number of degenerate forms hardly discernible are intermingled with above.

After 240 hours bacillary forms are rare, the field consisting chiefly of faintly stained large coccal forms, the diameter of which ranges from $\cdot4\mu$ to $1\cdot2\mu$, contrasting with organisms of an equal age when cultivated on glycerine agar. Scattered throughout the field are occasional deeply stained coccal forms.

After lapse of a month the organism has lost all its affinity for the stain, but is still visible in carefully prepared preparations as a faintly stained, irregularly shaped microbe, the transverse axis almost equalling the longitudinal.

In 50 days the field consists of very faintly stained débris, and what appears to be organisms which have lost all characteristic shape. There is, however, a good sprinkling of well-stained forms, chiefly of a coccal shape, though occasional rod forms with slight differential staining exist here and there.



FIG. 5.

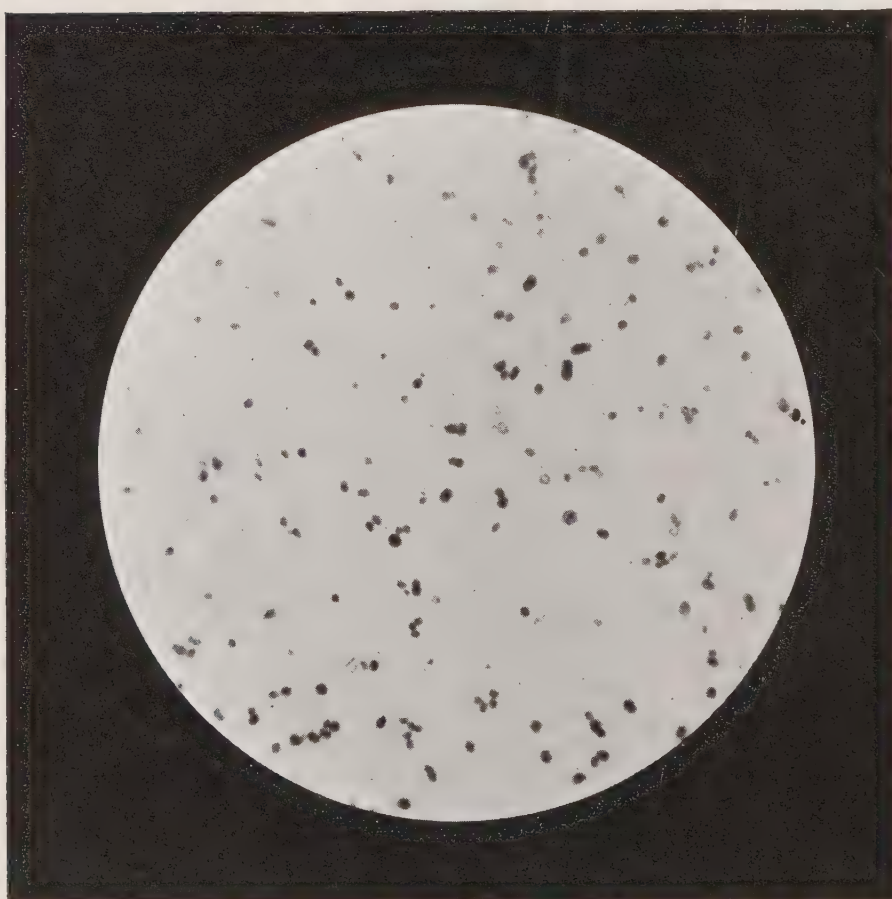


FIG. 6.

On subculture of this 50-day organism, and even after the lapse of 75 days, the original typical form reappears in 48 hours.

Gelatine.—After 48 hours' incubation at 22° C. the tendency to formation of long curved threads is marked, while a general tendency to elongation of the individual bacilli is noticeable, with corresponding decrease in the proportion of coccal forms. The average length of the organism after 48 hours' incubation is about 1.75μ (see Fig. 5).

In 96 hours thread forms are less noticeable, while the more normal coccal forms are general. No signs of degeneration or involution are present at this period, and the individual bacilli stain vigorously.

In 12 days the long thread forms are noticeably decreased, and the organism has less affinity for the stain. Elongated slender forms, however, are still frequent.

In 30 days all thread forms have disappeared, and the field is filled with small coccal growths, staining faintly, with frequent spherical bloated involution shapes (see Fig. 6).

(3) *Glucose Agar.*—In 48 hours a very scanty field exists. Normal forms occur without differential staining, but the majority consist of small coccal forms.

In 72 hours the field is still very scanty, small coccal and diplococcal forms staining deeply, but showing very little tendency to bipolarity. In 96 and 144 hours the growth is still very scanty, and the field shows masses of faintly stained bacilli, giving the impression of disintegration and degeneration. In addition to these, well-formed, deeply staining organisms occur, which are separate and ungrouped. Occasional forms exist from 3μ to 4μ in length, but differential staining is absent throughout.

In 10 days at 37° C. disintegration is far advanced. Fields consist chiefly of aggregations of faintly stained small ovoid and bacillary bodies with an occasional thread.

In 20 days at laboratory temperature, however, the growth from the moist portion of tube consists of elongated bacilli, contrasting markedly with parallel growth on agar.

In 50 days the appearances are somewhat remarkable, the field consisting of slender, elongated forms of bacilli varying in thickness, becoming alternately thicker and thinner, the transition being gradual. The extremities of these forms are either bulbous or tapering. In parts of the field these thread forms will be found to form a tangled skein of much intricacy (*vide* Fig. 13). Coccal and ovoid forms have ceased to be visible, but all gradations in length exist in the bacillary forms. On a retransplantation of this 50-day abnormal form of the *Bacillus Pestis* to plain agar vitality is rapidly re-established, so that a 72-hour culture shows aggregation of elongated and well-stained bacilli, intermixed with masses of *débris* from the old growth.

It is further worthy of note that the 50-day growth on glucose agar, consisting of yellowish, raised, desiccated-looking colonies, resist disintegration by the platinum loop to a considerable degree.

On transplantation from this medium after 75 days no growth resulted.

Litmus Agar.—No special appearances are noteworthy. The tendency to alkalinity in old cultures (up to 8 months) has already been noted.

Glycerine Agar.—The general size of the organism is noticeably increased, while its contour is less defined. Differential staining in 48 hours is more marked than



FIG. 7



FIG. 8.

Face p. 103 (a).

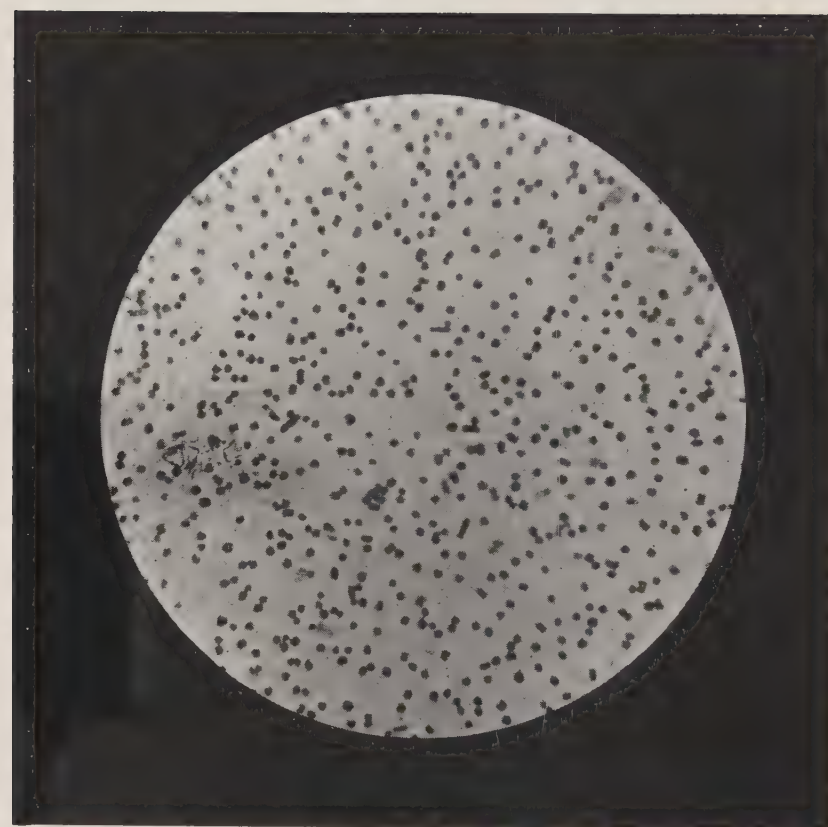


FIG. 9.

Face p. 103 (b).

upon agar ; coccal forms greatly predominate. Staining is not always bipolar, but seems in many organisms to be disposed irregularly on the short axis of the bacillus. The average length of an early culture on this medium is 1.49μ as against 1.06μ upon agar agar. The transverse measurement is also noticeably increased, being $.968\mu$ as against $.708\mu$ upon agar.

Tendency to capsulation has been observed in some specimens, but this appearance is inconstant and of doubtful value in consideration of the morphology of the bacillus. Tendency to thread formation is present. Occasionally, on this medium in early cultures, marked involution and irregular thread forms occur, as is often the case on rabbit agar (*see* Fig. 7).

In certain instances, the early 48-hour growth upon some samples of this medium gave the striking appearances as depicted in micrograph 8. Irregular branched and twisted forms, alternating with thick, elongated, or club-shaped forms appearing occasionally in this medium, tend to show the extreme polymorphism of the *Bacillus Pestis*.

Some of the twisted, branched forms as shown above appear distinctly segmented ; dichotomy proper, however, is always absent.

In 72 hours the appearances are not markedly altered. Occasional faintly stained large bacilli, three times the length and twice the breadth of the normal organism, are present. The majority of the field, however, is composed of coccal and diplococcal, with some thread forms which stain deeply (*see* Fig. 9).

In 96 hours coccal and bacillary forms predominate, showing marked bipolarity. The giant forms noted under 72 hours are increased in both diameters, and, while staining faintly, as a rule are occasionally deeply colored. Many leptothrix forms are present.

In 144 hours polymorphism is more marked, club and baton forms are occasionally present, while the giant forms as above persist, and are irregular in their chromotism. Thread forms are frequent, forming involuted tangled masses, presenting a remarkable divergence of appearance from the normal type of bacillus.

In 240 hours the majority of forms consist of ovoid or spherical forms, these latter being as large as from 1.5μ to 2.5μ in diameter. The staining is markedly deeper than in agar of corresponding age; bacillary forms are also more numerous than in agar.

In 30 days well-stained bacillary forms again predominate, in some cases being elongated into threads of irregular thickness from 4μ to 6μ in length.

A groundwork or matrix of faint "ghost-like" forms exists, in which large, irregular, and pale or coccal forms predominate. In 50 days signs of degeneration of the bacillary bodies are general, but there is a good sprinkling of deeply stained bipolar organisms. These deeply stained apparently virile organisms are apparently embedded or in close relation with the disintegrating forms, and in many cases a fragment or end of some of these degenerate forms is deeply stained, giving the impression of the greater longevity or survival of the part of the organism perhaps in connection with its proliferation.

Long, slender, and curved forms are occasionally present. Retransplantation at this period rapidly produced typical appearances.

After 100 days upon this medium the evidences of degeneration are much more marked, although, as will be seen under the heading of vitality, the organism retains its pathogenic and proliferative powers.

Salt Agar (2.5 per cent. NaCl).—The involution forms upon this medium are marked from the earliest



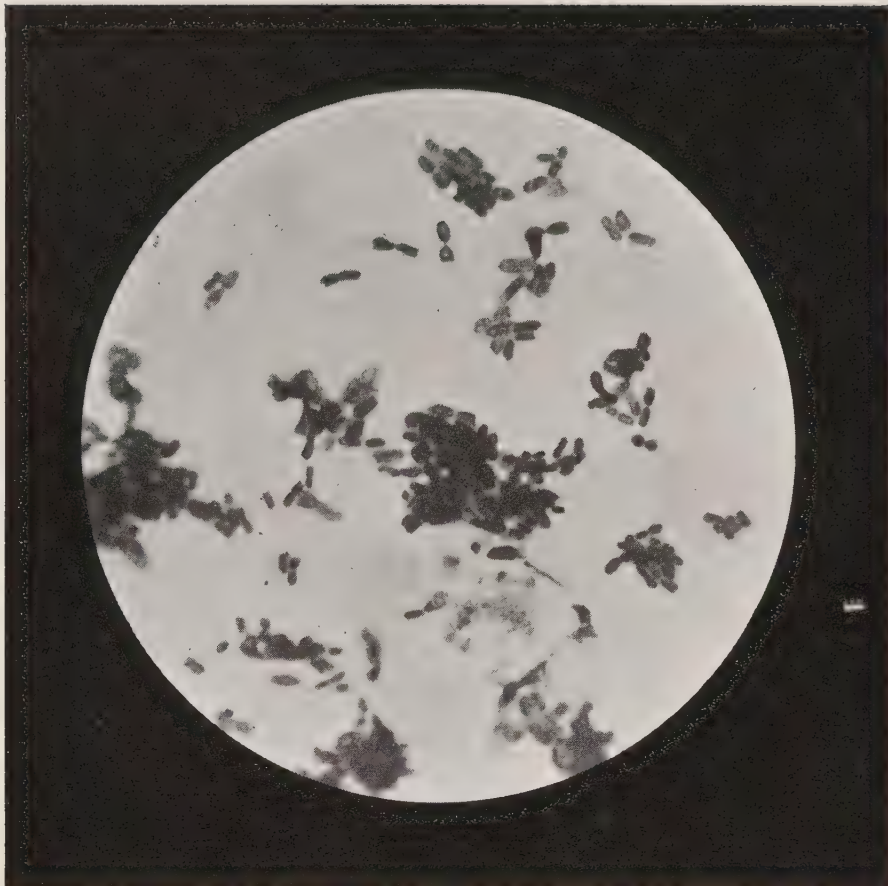


FIG. 10.

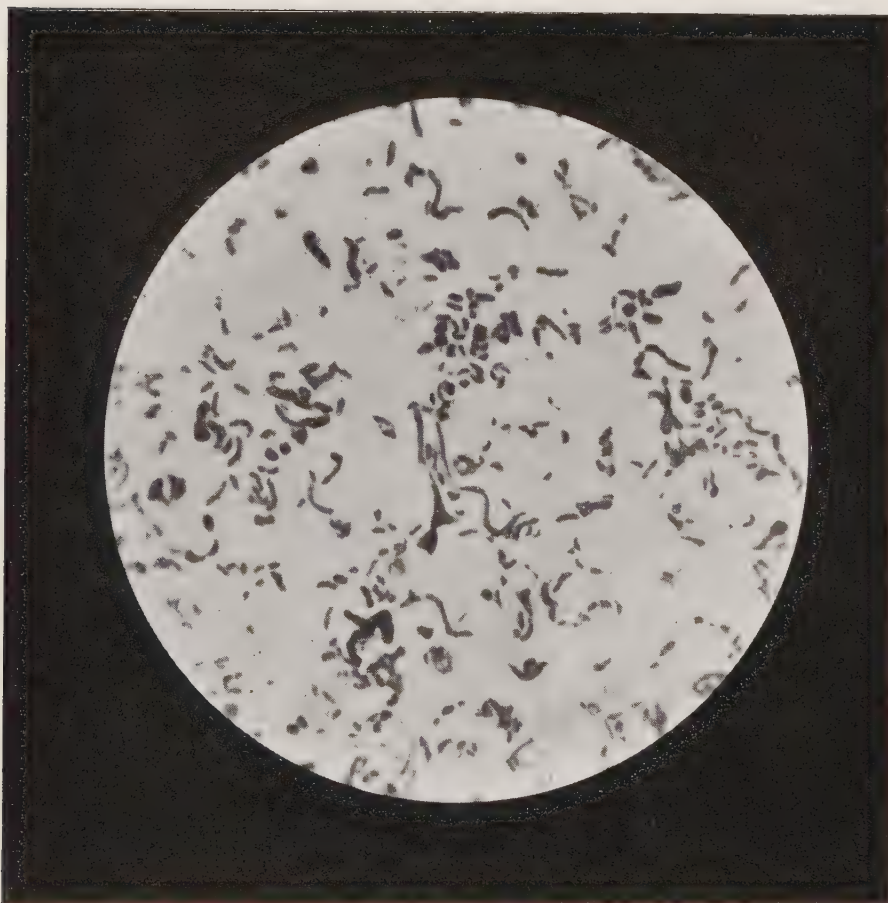


FIG. 11.

Another point of interest in connection with this medium is that where the organisms grew at Laboratory temperatures they remained in a fair state of preservation even after 100 days. One transplantation to same medium when 75 days old resulting in appearance as shown in Fig. 11.

incubative period. In 48 hours many long thick forms, seldom straight, are visible, showing no differential staining; many strange tadpole, pear-shaped, and irregular forms exist. Occasional normal forms are seen, showing differential staining. The aggregation of bacillary masses is noticeable.

In 72 hours involution forms are very frequent. All organisms stain well, and are firm, though very irregular in outline; large bloated dumbbell and spherical forms exist.

In 96 hours involution forms and aggregations of bacilli are not perhaps so marked. Many organisms assume the shape of a square or parallelogram, with the ends sharply truncated (dice box shaped), and often even concave (*see* Fig. 10).

In 144 hours little difference is observable.

In 240 hours disintegration far advanced, outlines of organism begin to be lost.

In 30 days an irregular, lightly stained, semi-granular mass results, showing very occasionally an organism faintly seen and very degenerate.

In 50 and 75 days these appearances are increased, appearing little more than an amorphous mass of faintly staining débris. Reference to the question of vitality, however, will show that even after 100 days the bacillus had not lost its power of propagation and pathogenicity.

Another point of interest in connection with this medium is that where the organisms grew at laboratory temperatures they remained in a fair state of preservation even after 100 days. One transplantation to same medium when 75 days old resulting in appearance as shown in Fig. 11.

Rat Agar.—A vigorous, deeply staining organism results from cultivation upon this medium. Thread

or leptothrix forms are frequent, measuring 20μ to 30μ in length or longer. The coccal forms chiefly present are slightly larger than those upon agar, being 1.164μ by $.756\mu$ in breadth as against 1.066μ by $.708\mu$.

The vigour of growth of the organism upon this medium has already been referred to under cultural characteristics.

Rabbit Agar in 48 hours gives typical appearance. Occasionally, on freshly prepared moist rabbit agar, inoculated directly from gland of human being, marked thread forms (see Fig. 7) of irregular breadth result, or sometimes involuted twisted threads, not unlike the leptothrix forms seen in an actively growing culture of *Bacillus Anthracis*. This property of thread formation has been observed in a number of various media, both moist and partly dried out, and is therefore probably connected with moisture available to growth of the bacilli. The thread formation has not been noticed to be restricted to individual colonies.

Ox Serum gives typical discrete organisms, small, deeply staining, but not differentiating in 48 hours.

In 72 hours there appears a slight tendency to degeneration, a number of the small coccal forms staining but faintly.

In 96 hours a distinct tendency to elongation is noticeable, while the whole field is stained but feebly.

At 144 hours the organism generally has lost all power of staining, with exception of a few typical young forms which are deeply colored and normal in appearance.

At 240 hours at 37° C. the degenerative appearance of those polymorphic forms so characteristic of some other media is noticeable. With a lengthy sojourn on the medium at laboratory temperatures, the organism appears to regain to some extent its power of staining,

and at the end of a month is seen fairly stained in the small coccal state.

At the expiration of 56 days some well-stained ovoid organisms stand out on a background of broken-down degenerate bacillary forms.

The organism on ox serum retains its vitality and typical appearance to some extent up to 100 days. Its virulence at this age proves absence of real degeneration, and when retransplanted on to ox serum it rapidly assumes its usual small vigorous-looking and deeply staining appearance.

Beef Bouillon.—The characteristic appearance in 48 hours in this fluid medium is chain formation of from 4 to 6 elements, or more. These elements show bipolarity, and more nearly approach the typical organism isolated from tissues, being, however, slightly smaller.

After 240 hours' incubation involution forms appear occasionally amongst the elements composing the filaments which tend to zooglea formation; but this feature is not well marked. Deeply stained chains can frequently be seen superimposed upon chains of pale, ghost-like elements, evidently degenerate, and contrasting markedly with the chains of younger growths.

After the expiration of 30 days the degeneration of the organism is more advanced. Elements swollen and irregular in shape coalesce, forming a network of chains faintly stained, and entangling other chains of well-stained elements.

The bacillus in this medium retains its vitality up to 100 days, though the microscopic appearances show excessive bacillary degeneration.

Glycerine Bouillon.—The organisms are larger and plumper in this medium than in plain bouillon, with a tendency to bipolarity. Clusters occur. Chain formation occurs (*vide* Fig. 15). Evidences of degeneration

occur at 72 hours, when certain elements of a chain lose their staining power, while other bacilli of the same chain remain prominently colored. The terminal organism of a chain is frequently seen bloated and involutioned. Decolorised chains of elements are frequent at 72 hours. After an incubative period of 96 hours involution forms are more frequent, occurring sometimes in the middle of a chain ; signs of degeneration at this advanced age, however, are not so pronounced as in plain bouillon.

In 240 hours at 37° C. the affinity of the elements of the chain for the stain appears almost lost. Masses of deeply stained material, however, can be seen adhering to these almost colorless networks of chains, giving an appearance to the field of large, rounded, or irregular masses of deeply stained material, connected by a faint tangle of colorless bacilli, the elements of which are slightly segmented.

After a further period of 20 days' incubation at normal temperatures the bacilli appear to regain their staining properties to some extent, so that the field shows a number of well-defined coccal forms ; such forms, however, are small and show no bipolarity. After 50 days at normal temperatures a tendency to elongation is noticeable. Leptothrix forms exist, and some involution shapes appear. The elongated elements become bulbous or pear-shaped. These appearances are increased after 75 days (*see* Fig. 16), and after the lapse of this time the bacillus can be recovered with ease by retransplantation into glycerine bouillon, in which many thread forms can be seen (*see* Fig. 17). The occurrence of these thread forms in liquid media is noticeable, as the suggestion has been made that such forms are directly connected with the dryness which ensues with the lapse of time on solid media.

Glucose Bouillon.—Chain formation is marked, the elements appearing smaller than in other liquid media. After 10 days appearances of degeneration are marked ; occasionally, small, deeply stained, single coccal forms are observable. In 50 days the large irregular masses noticed in beef bouillon are present in great numbers, and faintly stained chains of organisms with occasional elements more deeply stained here and there. The appearances of these masses often suggest that they are composed of a close agglutination of degenerated bacillary bodies, as frequent microbic forms can be detected, forming apparently part of the mass.

Salt Bouillon (2.5 per cent. NaCl).—A frequent point of remark in this medium is the clear-cut squareness of the organism, a chain of elements with sharp transverse divisions frequently resulting, recalling somewhat the appearances of the *Bacillus Anthracis*. Faint transverse striation shows a disposition to differential staining. After 30 days in 5 per cent. salt-ghee-bouillon at normal temperature, the organism shows but slight sign of degeneration and but little tendency to involution forms ; but when incubated at 37° C. in tubes containing small quantities of the medium the growth is much slower, and degenerative changes and involution forms become rapidly well marked.

On Rat Bouillon.—The growth is rapid and copious (as remarked under cultural observations), the microscopic appearances are those of beef bouillon, with better-filled fields.

In connection with the subject of the characteristics of growths at varying ages and under varying conditions of culture, it should be noticed that growths which, after lengthened periods of incubation, show upon examination organisms advanced in apparent degeneration are still able upon transference to fresh

media to produce vigorous cultures within the usual period.

Thus reference to the accompanying micrographs will show the vigorous growth of the *Bacillus Pestis Bubonicæ* produced by a single subculture from the old and degenerate organisms (*see* Figs. 12 to 17).

It will be also observable that prolonged culture upon a medium may result when retransplanted in a marked divergence from the shape of the organism as originally sown. Thus, in the above case of glycerine bouillon, the young growth as originally obtained from this medium, and the young growth as obtained by retransplantation from a 75-day culture, show distinct differences, the power of chain formation being apparently lost and giving place to a thread or leptothrix formation, besides other points of minor difference. In the case of beef bouillon this power of chain formation is still retained, however.

Another point of considerable importance in observing the morphology of this organism is the extreme difference observable in the bacilli growing upon the top of the nutrient slope (*vide* Fig. 18), and those taken from the depth of the same tube (*vide* Fig. 19), where the medium is thickest. The accompanying photomicrograph illustrates this fact, which is connected probably with the amount of moisture available to the bacterial growth.

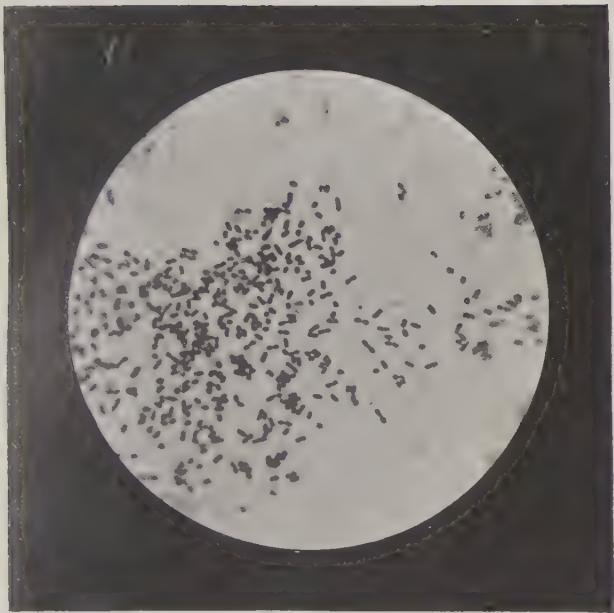


FIG. 12.
ORIGINAL GLUCOSE-AGAR GROWTH.

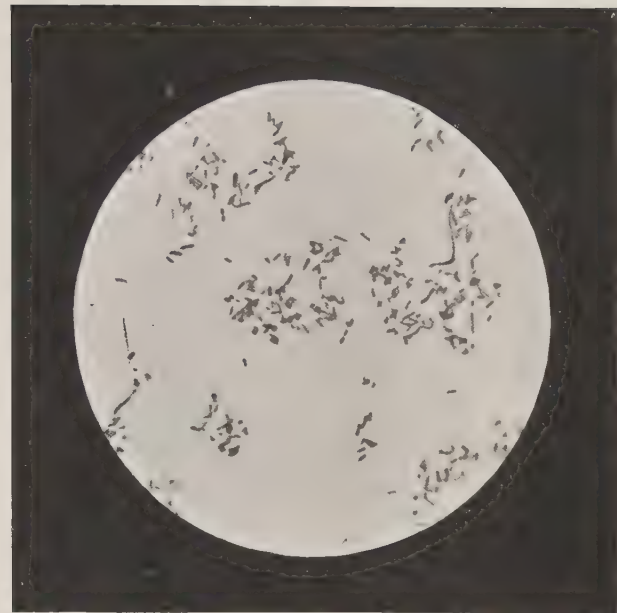


FIG. 14.
RETRANSPLANTATION FROM 13.

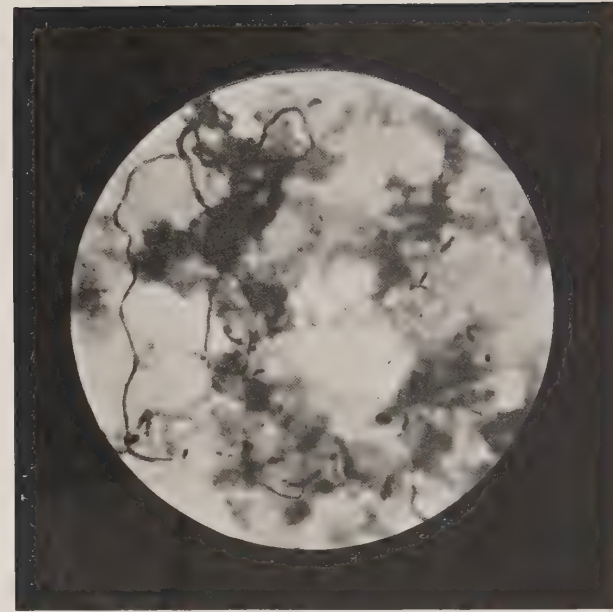


FIG. 16.
75-DAY GLYCERINE-BOUILLON



FIG. 18.
PLAGUE ORGANISM GROWING AT TOP OF AGAR SLOPE.

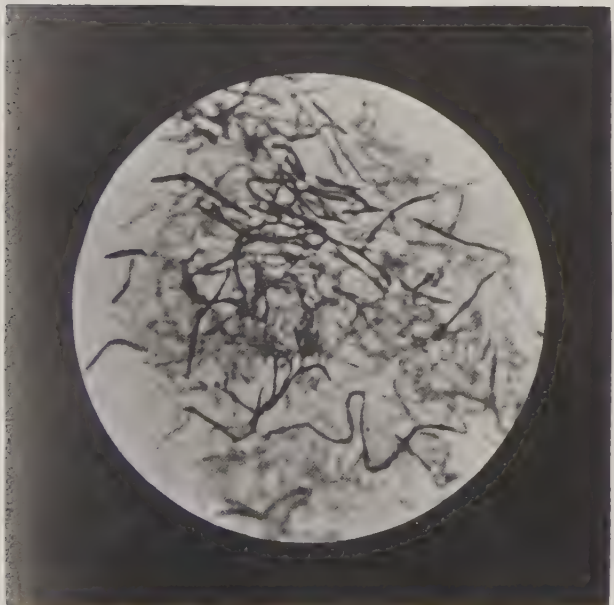


FIG. 13.
50-DAY GLUCOSE-AGAR GROWTH.
Face p. 110 (a).



FIG. 15.
ORIGINAL GLYCERINE-BOUILLON GROWTH
Face p. 110 (b).



FIG. 17.
RETRANSPLANTATION FROM 16.
Face p. 110 (c).

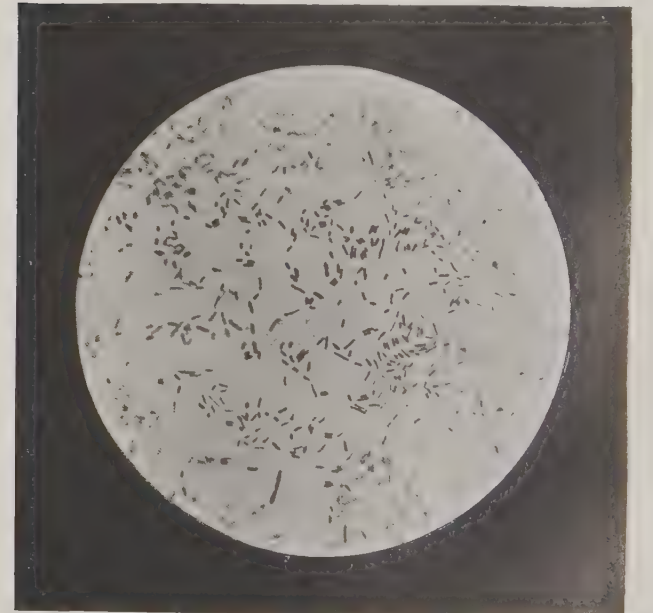


FIG. 19.
SAME ORGANISM GROWING AT LOWER END OF SAME SLOPE.
Face p. 110 (d).

SECTION IV.

VITALITY AND VIRULENCE OF *BACILLUS PESTIS BUBONICÆ*.

IN endeavouring to estimate the period during which the Plague organism retains its vitality under the conditions of normal laboratory temperatures, media, etc., it was found that after 50 days' culture in bouillon with 2·5 per cent. NaCl the organism was incapable of further growth when retransplanted upon other media.

After the lapse of 75 days the sowings from glucose agar and glucose bouillon also proved to be sterile when inoculated upon other fresh media.

In the estimation of the virulence of these growths it was found that after 100 days' culture glycerine agar, ox serum, salt agar, glycerine bouillon, plain bouillon proved fatal to guinea-pigs inoculated with them, while agar at this period had lost its virulence.

Reference to the following table of relative virulence will show the various periods of incubation, weights of animals and quantity of infective material being rendered as uniform as possible.

In the endeavour to estimate the degrees of difference existing in organisms isolated from man and the lower animals, no great points of variance were observable.

Mere sojourn in the animal system does not appear, however, to induce any pronounced degree of attenuation of virulence, as the following instance tends to show. A rat resisted inoculation with a virulent growth for

23 days, and at the expiration of that time, while still in vigorous health, was killed and examined. No abnormality was observed to exist in the cadaver beyond the existence in the groin of a hard, enlarged gland, non-hæmorrhagic, and without peri-adenitis. Upon section it was found to contain a drop of thick pus, in which but few organisms could be detected.

VIRULENCE OF BACILLUS PESTIS AFTER LAPSE OF 100 DAYS WITHOUT
RETRANSPLANTATION.

<i>Medium.</i>	<i>Dosage.</i>	<i>Date.</i>	<i>Result.</i>	<i>Duration.</i>
Agar	1 loopful	June 4	Recovered after temporary illness.	
Glycerine agar	"	"	Died June 11	158 hours.
Ox Serum ..	"	"	Died June 13	205 hours.
Salt agar ..	"	"	Died June 14	230 hours.
Glucose agar ..	"	"	Survived, practically no illness.	
Salt bouillon ..	1 c.c. after agitation	"	Survived after practically no illness.	
Glyc. bouillon	"	"	Died June 9	113 hours.
Glucose bouillon	"	"	Recovered after mild illness.	
Bouillon	"	"	Died June 16	277 hours.
Control ..	Scratch in thigh, 1 loopful B. Bouillon	"	Died June 11	158 hours.
Control ..	"	"	Died June 16	283 hours.
Control ..	"	"	Died June 9	118 hours.
<p style="text-align: center;"><i>Average Duration—old cultures—196.6 hours.</i> <i>Average Duration—recent cultures—186.3 hours.</i></p>				

Upon cultivation, however, a typical growth resulted which proved extremely virulent for guinea-pigs. How long the organism would have maintained its vitality in its live environment is, of course, conjectural; the fact, however, remains that the animal resisted the infection, and, while still harbouring the virulent organism in a latent condition, remained itself in perfect health,

and capable under accidental conditions of spreading the infection.

Source of type of organism would seem to have little or no influence upon the question of its virulence, and reference to the table above will show that age within certain limits is also negligible in this connection.

The influence of burial upon the vitality and virulence of the bacillus is a subject of much importance from the point of view of the safe and efficient disposal of the bodies of persons succumbing to the disease. With a view of showing the length of survival of the Plague germ under conditions of ordinary interment, several experiments were undertaken. Two guinea-pigs were infected with virulent human Plague. Upon decease the body of one of these rodents was enclosed in a box made of half-inch deal, and the other cadaver was loosely wrapped in a piece of linen. These bodies were buried in a grave 5 feet deep in soil adjoining a burial-ground. The nature of the soil was sandy, with a substratum of fine gravel. After an interval of 108 days these bodies were exhumed and examined. The box was in good preservation, the wood being slightly damp. The decomposition of the cadaver was advanced, the limbs being detachable with a slight pull, while the viscera were found to be almost diffuent and recognisable with difficulty.

Two guinea-pigs were inoculated subcutaneously with an emulsion taken from viscera (probably the spleen). No illness resulted, and plates inoculated from same material showed no suspicious growths.

In the case of the guinea-pig buried in the cloth, the appearances of decomposition were very similar. Two healthy guinea-pigs inoculated with emulsion from spleen remained healthy ; but in plates made from the same an organism was isolated, somewhat resembling

Bacillus Pestis culturally and microscopically. This organism proved, however, to be actively motile and non-pathogenic, even in large doses.

A further opportunity arose for elucidating the question of the survival of the Plague bacillus in the case of a human cadaver, which it was found necessary to remove from the original place of interment after an interval of 190 days. In this case also the endeavour to isolate the organism from the viscera was unsuccessful, both by live inoculations and also plate cultures. It is, therefore, reasonable to infer that either the Plague bacillus loses its vitality after a period of a few months, or that it loses its morphology and virulence to such a degree as to become unrecognisable.

Further experiments were undertaken with the intention of showing the length of survival of the organism in soil.

A series of deep jars were filled with ordinary sifted loam, into the depth of which glass tubes of large calibre were plunged. Some of these jars were sterilised under a pressure of $1\frac{1}{2}$ atmospheres for 3 hours on three successive days, while in others the contained earth was inoculated in an unsterilised condition.

The depth of the column of earth was approximately 25 centimetres. Ten cubic centimetres of a culture—the virulence of which was controlled by eight rodents—were introduced through the tubes into the column of soil at varying depths, or simply poured in some cases upon the surface of the soil. These jars were carefully closed with sterile paper caps, and remained at laboratory conditions. The soil contained sufficient moisture to admit of cohesion upon being squeezed in the hand.

At the expiration of varying periods small portions of the soil were withdrawn from the sterilised and unsterilised jars, both superficially and at a depth of

1 centimetre, and also from the depth of the columns of earth. These small samples of earth were ground down with sterile bouillon, and the supernatant fluid was inoculated subcutaneously into healthy guinea-pigs.

The results were as follows:—At the expiration of eight days after infection of the jars the first series of animals were inoculated, with the result that the bacillus was recoverable from all the jars, both from the surface and depth of the earth.

After the expiration of a month the effort was repeated, and it was noticed that no ill effects followed the inoculation of material from either surface or depth of the *sterilised* jars. In the case of the guinea-pigs inoculated, both from the surface and depth of the *unsterilised* jars, a lengthy illness followed the inoculation, eventuating in one case (that of the animal inoculated with soil from the surface) in recovery, but ending fatally in the case of the guinea-pig inoculated from the depth of the unsterilised earth. In this latter instance the illness was prolonged, and an abscess resulted at the point of the operation, and commenced to suppurate a week after inoculation.

The animal died after an illness of 20 days, and from the pus of the abscess the organism of Plague was isolated from amongst several other bacteria. This proved pathogenic to other guinea-pigs within nine days, the *post-mortem* and cultural appearances confirming the cause of death.

After a period of five weeks a further series of inoculations were made, with an entirely negative result.

It is, therefore, reasonable to conclude that the bacillus is incapable of extended life in soil either on its surface or at a depth of about 1 foot.

Association in earth with other soil organism would not appear to act inimically to the life of the bacillus,

which apparently fails to maintain its existence by reason of its unfavourable environment.

This fact would tend to be confirmed by the results about to be detailed in connection with the vitality of the organism in granaries, etc., and helps, therefore, rather to favour the theory that the bacillus maintains its existence in the bodies of living animals, probably rodents. That it is capable of existence beyond a normal period in the bodies of living animals is shown by the instance of the guinea-pig above mentioned, and also in that of the rat which was inoculated, and killed when healthy 23 days afterwards, from whose bodies the *Bacillus Pestis Bubonicæ* was isolated.

Color. — An endeavour was made to ascertain the influence of colored light upon the vitality of the organism. For this purpose a series of Petrie dishes were inoculated, such dishes being covered with glass squares of varying colors. It was found, however, that no difference existed in the vigour of the growths in the green, blue, ruby, and yellow dishes, the growths in which were as well developed as those in the control colorless dishes, and appeared to maintain their vitality as long.

Sunlight. — The bactericidal effect of direct sunlight was approximately ascertained on growths exposed on agar in Petrie plates. Such exposure was made at midday, the time of the year being mid-winter, the light being very actinic, maximum shade thermometer 78° F., barometer 28.43, with dry bulb 62°, wet bulb 56°. Dishes were tilted to the direct sun rays. A portion of each dish was covered with a strip of opaque paper, affording shade for a streak of normal growth, which acted as a control to the rest of the dish.

An active bouillon culture was used, and the dishes were exposed to the light directly after inoculation.

Loss of vitality began to be observed in gradations after 10 minutes' exposure, 5 minutes giving no perceptible result. Growths also resulted on the plates exposed for 15, 20, 25, and 30 minutes, but a distinct inhibition of growth was noticed after 40 minutes' exposure, the area shaded by the strip of opaque paper showing, after the usual period of incubation, a well-defined band of growth, contrasting with the feeble development of the rest of the dish.

An exposure of 60 minutes' duration to conditions as above proved sufficient in all cases to completely inhibit the growth on that part of the agar unprotected by shade.

Vitality.—The question of the vitality and virulence of this organism under natural conditions being one of the first importance, an extensive series of experiments was undertaken at your suggestion in the endeavour to elucidate this point.

For this purpose 10 small brick houses or cubicles were constructed, each being furnished with cement floors and a window and door, affording no lodgment or chance of escape to the rodents confined in them. The cubic capacity of these boxes was 264 feet each. Each box was ventilated by four air bricks, covered on the inside with wire gauze of sufficient fineness of mesh to be fly and vermin proof. They were numbered 1 to 10. Arrangements were made for excluding the light from certain of these compartments, while to others the light had free access. In these boxes were placed bags of grain of varying sorts, such as oats, bran, flour, mealies, and mealie meal, besides trusses of hay, etc., and an endeavour was made to simulate as far as possible the conditions obtaining in a granary or produce store.

These boxes were surrounded by a high fence of

corrugated iron, carefully constructed, while the whole compound thus formed was covered or roofed in with inch wire netting, to obviate the possibility of any rodents, which might by any accident escape from the boxes, leaving the premises and so spreading the infection.

It was found that the rats were capable of maintaining an absolutely healthy condition when such boxes remained uninfected. Thus, for many months one of the above boxes has served as a receptacle for healthy reserve or control rats, which have lived in large numbers and propagated under the above conditions.

The rodents—of which some hundreds were obtained both from town dwellings and also from the wharves and shipping at the port—were the usual black and brown rats (*Mus rattus* and *Mus decumanus*).

Each box was infected in the first place by the introduction of from 8 to 10 rats, which immediately prior to introduction were inoculated subcutaneously with a platinum loopful of virulent bouillon culture, or a hypodermic injection of the same. The technique of such inoculations was as follows:—The tail of a healthy rat was seized with a large pair of ratchet forceps known as “snake-tongs,” used in the laboratory for the capture and manipulation of snakes in venom collection, and while held pendant by its tail the skin of the back of the neck was seized between the thumb and finger of one hand, while the other hand extended the body of the rat for the injection to be made. Some hundreds of rats were inoculated in this manner without serious accident. Such operations, however, were never devoid of exciting incident.

The endeavour of the above series of experiments was to show the length of time such repositories would

maintain their infectivity, whether conditions of light or darkness favoured the maintenance of the same, the efficiency of various processes of disinfection, and the infectivity from animal to animal.

It was hoped that the elucidation of such points would lead to an improved and more economical method of dealing with premises in which the contagium was known to exist.

The mortality occurring in these boxes was accurately observed daily from the time of the introduction of infected rats, such observations being either made through the glazed roof of each house, or, where necessary, by removal of the contained sacks, etc., after all possible precautions had been taken in such removal to avoid personal infection by dust, etc., in plugging of the nostrils.

When all the rats in one box had succumbed to the disease the boxes were closed for varying intervals, and at the expiration of such times fresh healthy rats were introduced into the boxes, and the infectivity or otherwise of such box decided by a lengthy observation of the occupants. A careful *post mortem* confirmed the cause of death in each case.

This method of judging as to the retention of vitality in the box was found to be reliable, as it was repeatedly observed that healthy rats introduced into a box in which the infection was comparatively recent rapidly succumbed.

Reference to Appendix B will show the details of this experimental work. In the present place a summary of these results is shown as follows :—

After the lapse of one month from the date of death of the last rat it was found that healthy rats introduced into the box contracted the disease ; this experiment was therefore positive at the expiration of 30 days.

After two months' lapse rats remained healthy when

introduced into the previously infected boxes, and the same negative result was found to attend those boxes which were shut up for more lengthy periods (up to four months). This experiment, extending over some six months, was conducted several times with different boxes, the rats so reintroduced remaining healthy. The result may therefore be considered conclusive, and it may be assumed that the infection of grain stores and other similar premises does not persist—in the absence of living rodents—over a period approximately of two months.

Influence of light on retention of vitality was practically negligible, and the exclusion of light did not tend to prolong the vitality of the organism (*vide* Appendix).

MEASURES FOR DISINFECTION OF BOXES.

Boxes which had been recently subjected to a thorough infection with many infected rats were chosen for the purposes of this experiment. It must be remembered in interpreting the results obtained that such boxes contained a number of small bags of grain, meal, etc., and some trusses of tightly baled hay, into which the rats had burrowed freely, presumably infecting the interior of such sacks and bales. These conditions, however, are such as obtain in general grain and produce stores, to which premises such results would seem applicable if similar methods of disinfection were adopted.

Sulphur Dioxide (5.3 per cent.).—The interior of the infected box and its contents was slightly damped with a fine spray of water before the SO_2 was generated. Sulphur was used in the proportion of 1 lb. to 200 cubic feet, and was consumed entirely by mixing into a paste with methylated spirit before ignition. The box was closed for 24 hours during the process, the

doors, window, and ventilators being carefully pasted over to prevent escape of SO_2 or access of fresh air. At the expiration of this time it was at once restocked with 6 healthy rats, which died of typical Plague within a few days (*vide* Appendix).

This experiment was repeated with a similar result in another instance.

Formic Aldehyde was generated in an infected box, the cubical contents of which were 264 feet. Five tabloids of paraform, an equivalent of 12 grammes of commercial formalin, were volatilised in this space by the Alformant lamp (the strength recommended by the manufacturers being 10 tabloids to 1,000 cubic feet). After complete closure of the box for 24 hours it was restocked with healthy rats, which rapidly succumbed to typical Plague.

It may therefore be safely assumed that the ordinary measures of disinfection with sulphur dioxide and formaldehyde are not efficient, even when in excess, in dealing with the conditions of contagion which are likely to obtain in granaries and other similar buildings where actual surface contact with the gaseous disinfecting agent is impossible or difficult.

Regarding the possibility of the direct transference of the infection from rat to rat, inconclusive evidence only was forthcoming, and the inquiry along this line was not very extended.

It was obvious, however, that the infection is capable of transference to the rat in the absence of other rats either sick or dead from the disease, and in the absence, as far as the closest scrutiny could show, of fleas and other vermin. When dead rats were allowed to remain in the boxes in which they had died, it was a matter of frequent observation that the rats surviving longest had consumed the bodies in whole or part of those

animals succumbing before them. This is probably a frequent, but cannot be a constant, factor in the spread of the disease from rat to rat. The agency of vermin in the transference of the disease from one rat to another must, however, be admitted as possible.

Time did not permit of exhaustive experiments in this direction. Two cases of transference of vermin which were floated off the bodies of dead rats, and at once placed in the coats of healthy animals, proved negative. Very many of the bodies of dead and dying rats were closely examined, and showed a remarkable freedom from vermin. In many cases no parasites at all were discoverable; seldom *Pediculi*, and quite occasionally rat-fleas (apparently *Pulex Pallidus*).

It seems, therefore, more probable, in view of the constancy with which healthy rats succumb when introduced, that infection is generally spread from animal to animal by the ingestion or inhalation of particles of infected matter, dejecta, etc., rather than by infection by means of vermin. This view seems strengthened when the short vitality of the bacillus (as shown in the box experiments above) is compared with the length of time fleas and their larvæ are capable of maintaining their vitality under favourable circumstances.

At the same time, the evidence of the agency of fleas as transmitters of the disease cannot be overlooked, and such instances of outbreaks following the removal of floors of infected premises where no precautionary measures for previous disinfection, damping, etc., have been taken, tend to confirm the flea-borne theory, which is further strengthened by the frequency with which the primary specific lesions in man are localised in the system of glands draining the lower extremities.*

* This argument could with equal force be employed in support of infection through the agency of dust on an abraded skin.—E. H.

Transmissibility from animal to animal.—The importance of the question as to the possible agency of the lower animals in the spread of the infection suggested the advisability of confirming the observations recently made on this point in Hong Kong. With this object in view, a series of experiments was made on the different domestic animals stated to have been found susceptible to Plague. The possibility of the contagium remaining latent, or in an incubative stage in the system (of, for instance, the pig or domestic fowl), and at the expiration of a lengthy period unexpectedly asserting its pathogenic properties, would appear to be so important a question in the epidemiology of the disease as to warrant careful confirmation of previous findings on this point.

A corroboratory investigation, therefore, was conducted on the lines of the recent inquiry of Professor Simpson in Hong Kong, and I may say at once that such investigation has failed in every instance to induce the fatal form of the disease which attended the experiments in China, to the results of which great importance has not unnaturally been attached.

Repeated endeavours have been made to induce a fatal form of the disease by the ingestion of infected material, and by the inoculation of virulent cultures and blood, as well as by close contact with an animal in a highly infectious condition (*vide* Appendix C).

The failure of the above inquiry to confirm the findings of the Report on Plague in Hong Kong cannot be attributed to any attenuation or loss of pathogenicity in the strain of bacillus used—at least, as far as its virulence for the human being and rodent is concerned—as all such inoculation experiments were conducted with cultures isolated direct from the cadaver, or, in the case of ingestion experiments, by the use of diseased tissues themselves.

The failure to confirm the transmissibility of Plague to the lower animals in a fatal form—as laid down in the Report referred to—can therefore only be explicable upon the assumption that the strain of bacillus used in the experiments in Hong Kong was possessed of a wider range of pathogenic properties, which, while being equally virulent with the Natal organism for men and rats, was possessed of additional or increased pathogenicity for other of the lower animals. Recent studies in immunity would seem to bring such a theory within the bounds of possibility.

That so considerable racial immunity should exist special to South African herbivora, pigs, and birds seems untenable in consideration of the ordinary susceptibility of rats and of man himself.

Insufficiency of data can, however, fairly be urged against the Natal observations, though it will be seen on comparison that the disparity in numbers of cases between the Hong Kong and Natal experiments is not very great. Thus, while of 31 hens subjected to experiment in Hong Kong 9 died (29 per cent.), of the 20 hens treated in Natal none succumbed or were ill; and similarly, while of the 15 pigs experimented upon by Professor Simpson 86 per cent. or 13 died, of the 10 pigs similarly treated in Natal none died, and but 1 showed a transient illness, due to manipulation. Reference to Appendix II. will show details of treatment in all cases coming under observation, which comprised pigs, calves, and fowls.

Even were the direct connection of such animals with the maintenance of an epidemic proved, it would seem easy to over-estimate the significance of a fact, which would be one rather of academic interest than practical importance.

The ingestion of human tissues by the pig, ox, or

even rat, is a sufficiently remote contingency to be dismissed, while the actual inoculation from or consumption of the flesh of Plague-stricken animals by the domestic animals of the large towns in which the Plague is most endemic, would seem also negligible in consideration of its epidemiology.

The conclusion, therefore, seems warrantable that, so far as Natal is concerned at least, these animals are not to be looked upon as factors concerned either with the spread of the disease or with its periods of latency.

SECTION V.

BACTERIOLOGICAL DIFFICULTIES ENCOUNTERED IN COURSE
OF THE OUTBREAK.

As mentioned previously, considerable difficulty was encountered throughout the continuance of the epidemic in making a diagnosis from the microscopical appearances available. In fact, so grave did this difficulty become, that, even when supported by the clinical history, it was found advisable in many cases to defer a definite pronouncement until the cultural characteristics and virulency of the organism in question had been observed. A dependence upon the indications of the microscope simply in several important instances could not but have resulted in an erroneous positive pronouncement, with all its serious attendant consequences.

This difficulty does not appear to have occurred to any extent during outbreaks of Plague elsewhere.

The thoroughness of the means employed by the Health Department for the detection of early cases of Plague, and for the routine *post-mortem* examination of all cases in which the cause of death was not clearly apparent, has doubtless frequently accounted for the observation of microbic forms nearly allied morphologically to the *Bacillus Pestis*. Attention has been drawn in Appendix A to the possibility of the occurrence of forms of organisms in the tissues of rats indistinguishable microscopically from Plague bacilli (Fig. 24), so

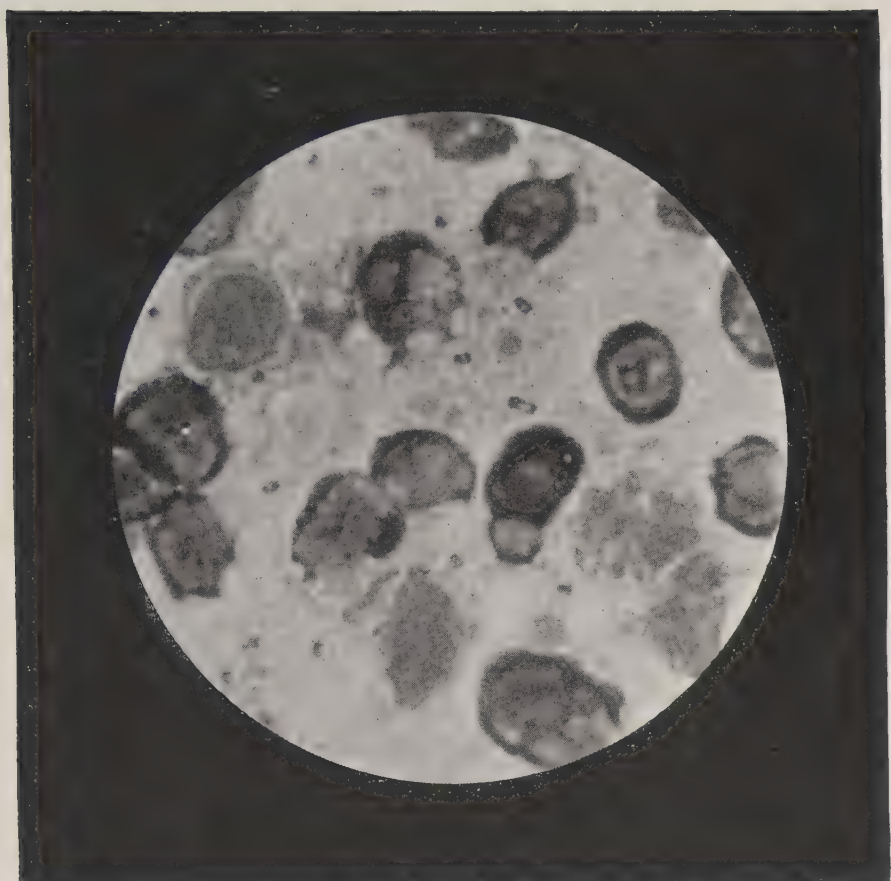


FIG. 20.

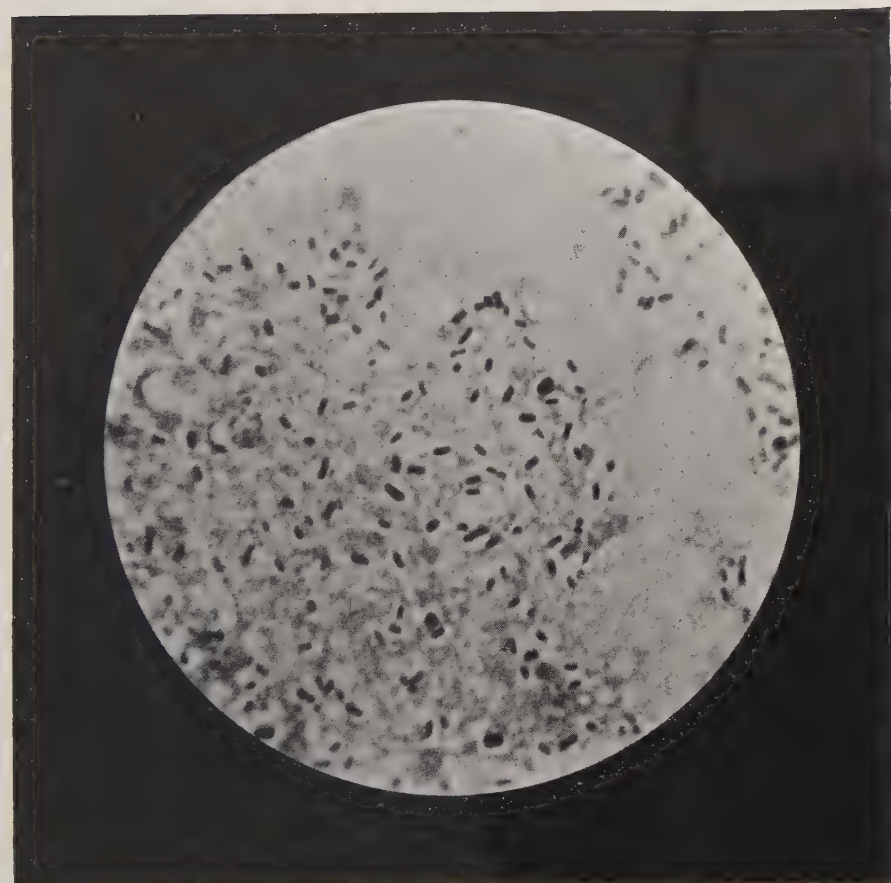


FIG. 21.

Face p. 127 (a).

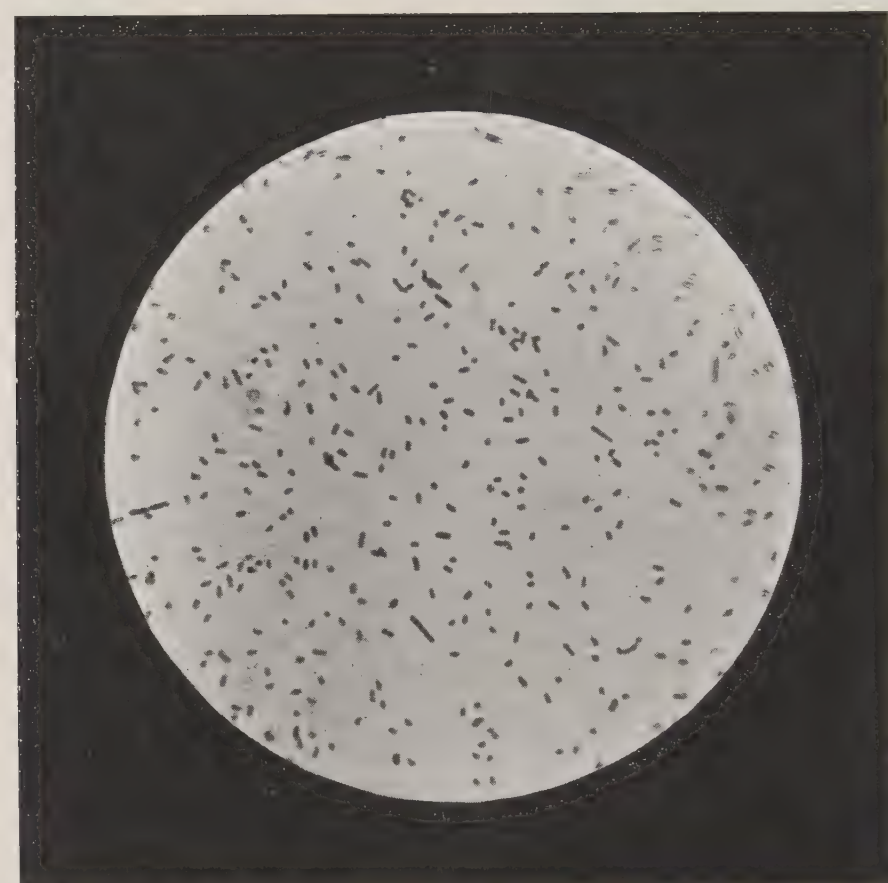


FIG. 22.

Face p. 127 (b).

that the same difficulty applies to the diagnosis of the disease in other than the human species.

A few instances of such cases may be quoted here, to exemplify the necessity of cultural observations being made to support bacterioscopic appearances.

Case No. 1.—The history of the case was as follows :—A Kaffir male was found dead in Pietermaritzburg during the prevalence of the epidemic. *Post-mortem* examination revealed pleuritic effusion and unilateral broncho-pneumonia. Portions of the internal organs in good preservation were forwarded at once to the Laboratory. Spleen smears showed an apparently typical Plague organism in pure culture (*see* Fig. 20), and upon this observation an affirmative diagnosis was at once made. Upon culture of the organism, however, points of difference became obvious, for while the bacillus showed bipolarity and was pathogenic for guinea-pigs, it produced also so rapid and diffuse a growth, and such atypical *post-mortem* appearances, as to lead to a re-decision as to the specific nature of the case (*see* Appendix A).

Case No. 2.—Tissues taken from a man were forwarded for examination without definite clinical history. The appearance of the organism in smears from the spleen where it appeared to exist in pure culture was highly suspicious (*see* Fig. 21). A guinea-pig was inoculated with an emulsion of organs, the bacillus proving pathogenic in 38 hours. Cultivations upon agar gave a rapid profuse growth, the organism tending to polar staining and appearing like a typical Plague cultivation on serum (*see* Fig. 22). Rapidity of growth and motility resulted in a negative opinion before a negative clinical history was received (*see* Appendix A).

In another case—that of a man taken suddenly ill upon premises in which previous cases had occurred—

the chief symptoms were referable to the lungs. Examination of the slightly blood-stained expectoration showed a highly suspicious organism apparently in pure culture, which, however, failed to produce death when injected into guinea-pigs and rats. This organism, therefore, was looked upon as being non-pathogenic, and proved to be so on more extended observation.

In another instance, a man was removed to the hospital in consequence of contracting typical Plague. Upon inquiry it was elicited that he was an assistant in charge of a poultry farm upon which the fowls, ducks, etc., had been dying in large numbers. Examination of tissues and blood from the bodies of these birds showed the existence of an organism with difficulty distinguishable from the Plague bacillus in appearance (*vide* Fig. 23), which proved upon culture to be the *Bacillus cholerae gallinarum*, pathogenic to guinea-pigs, but not to rats; fowls readily succumbed to the organism, but not to control injections of virulent Plague cultures.

The above instances are examples of an often-recurring difficulty encountered throughout the continuance of the epidemic.

The fact that Plague is liable to be associated with diseases such as that just described, in which the pathogenic organisms are indistinguishable from those of Plague proper, should therefore be borne in mind. Outbreaks of Fowl Cholera, Swine Plague, etc., are thus liable to confusion with Bubonic Plague if reliance is placed solely upon microscopic appearances to the exclusion of other means of exact diagnosis.

Some of the early cultural appearances also of such organisms as Fowl Cholera simulate the growth of the *Bacillus Pestis* (*see* Fig. 1), but extended observations on pathogenicity, rapidity of growth, and other

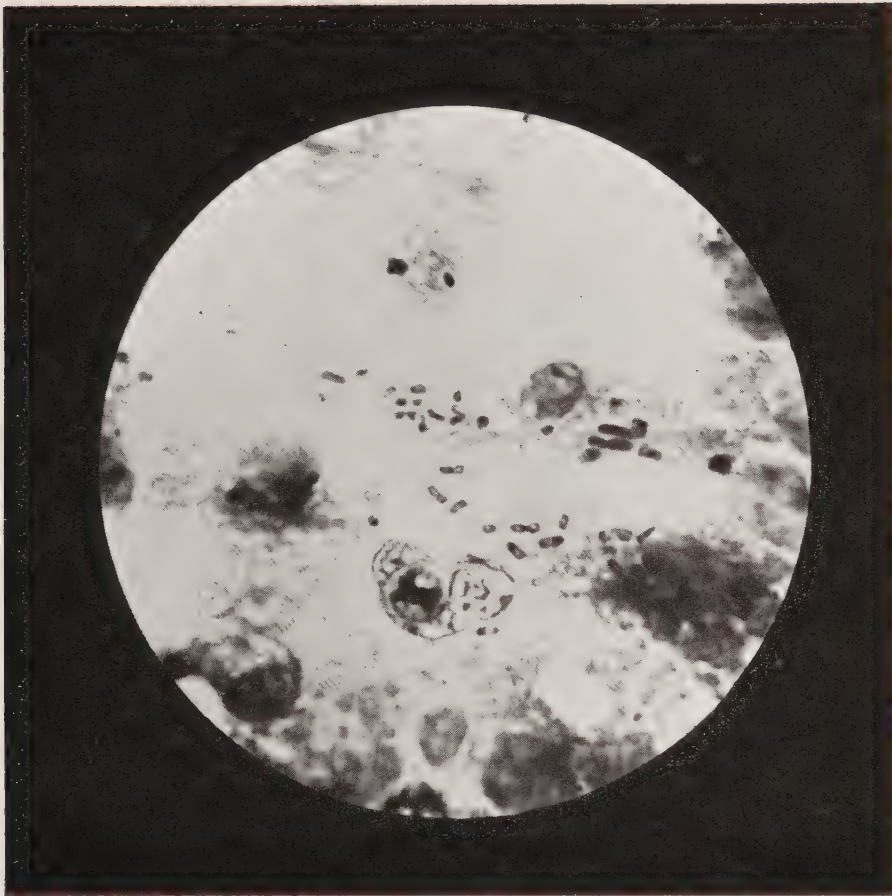
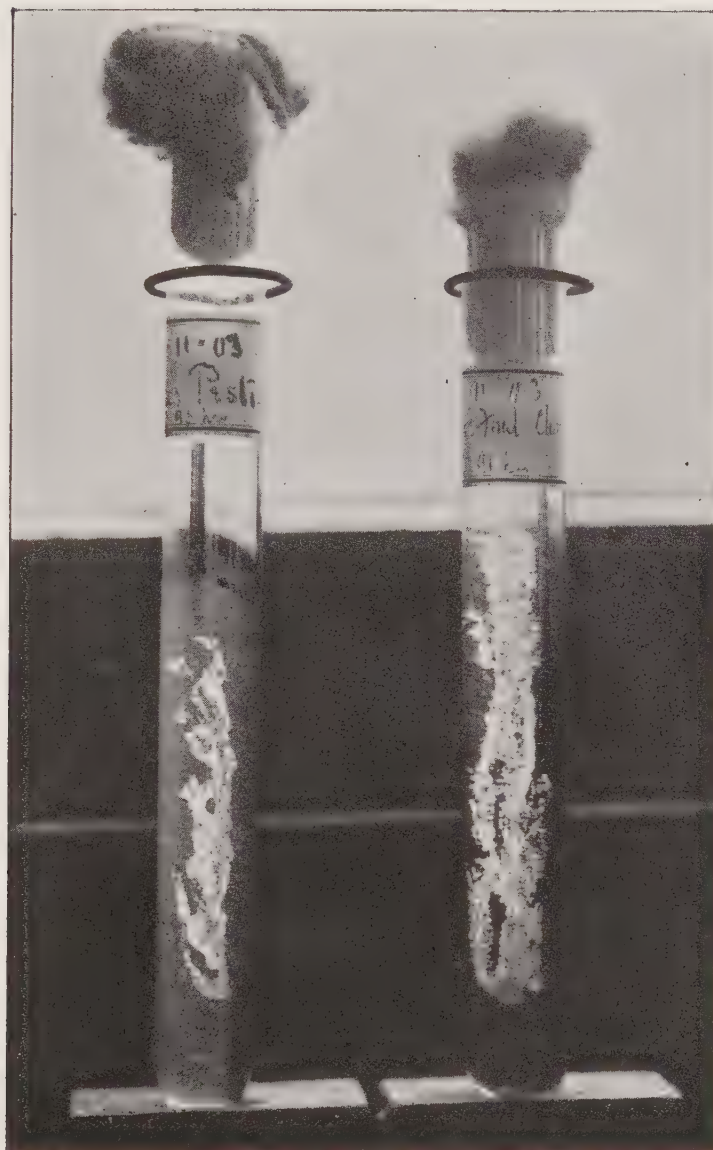


FIG. 23.

Face p. 128.



a

b

FIG. 1.

Face p. 128.

differences, cannot fail to afford means for exact determination.

The observations above embrace most of the important points in connection with the bacteriology of the disease. Consideration of time and other duties have prevented many of these points being dealt with in a more exhaustive manner.

I trust, however, that some of the above observations may not be without value in dealing with possible future outbreaks in our Colony and elsewhere of this universal scourge to mankind.

APPENDIX A.

I.

WITH reference to cultural appearances, Yersin mentions (and Tidswell of Sydney confirms the observation) that in many instances "small colourless and large cloudy colonies" are to be found growing side by side. Klein also, in the *Centralblatt für Bacteriologie*, July 10th, 1897, noticed the appearance of colonies contrasting markedly with their neighbours, being large, round or oval, consisting of longer or shorter straight or looped threads or bacilli, which he first regarded as contaminations, but subsequently considered such occurrence as a cultural characteristic of this organism. The same question has arisen in more than one instance in the present work.

In one instance—that of a culture made from a spleen of a rat within a few hours of its death from typical Plague—an appearance was found corresponding to the description above. In this instance, while the microscopic appearances of both growths were identical and typical (*see* Fig. 24), the cultural characteristics and pathogenicity as subsequently determined were widely divergent.

II.

Case 1 was that of a Kaffir male found dead. The *post-mortem* examination revealed some pleuritic effusion and a condition of broncho-pneumonia on one side. The spleen was friable and soft, and contained large numbers of bi-polar organisms. (*See* Fig. 20.)

Lung smears contained apparently the same organism.

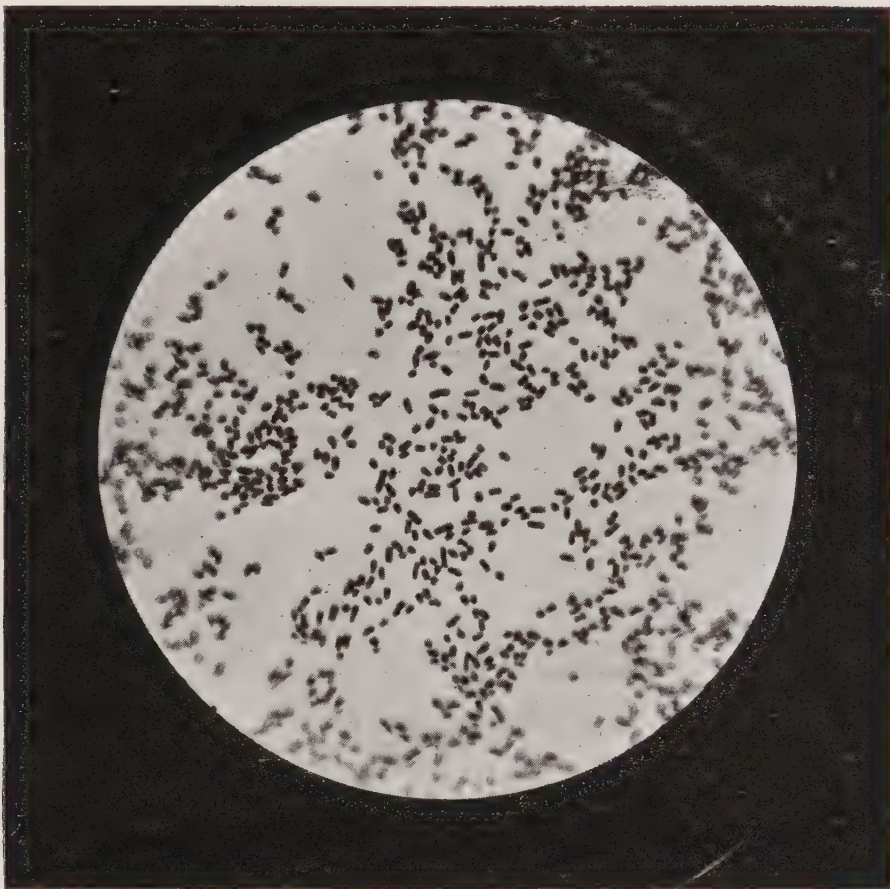


FIG. 24.

Fac p. 13.



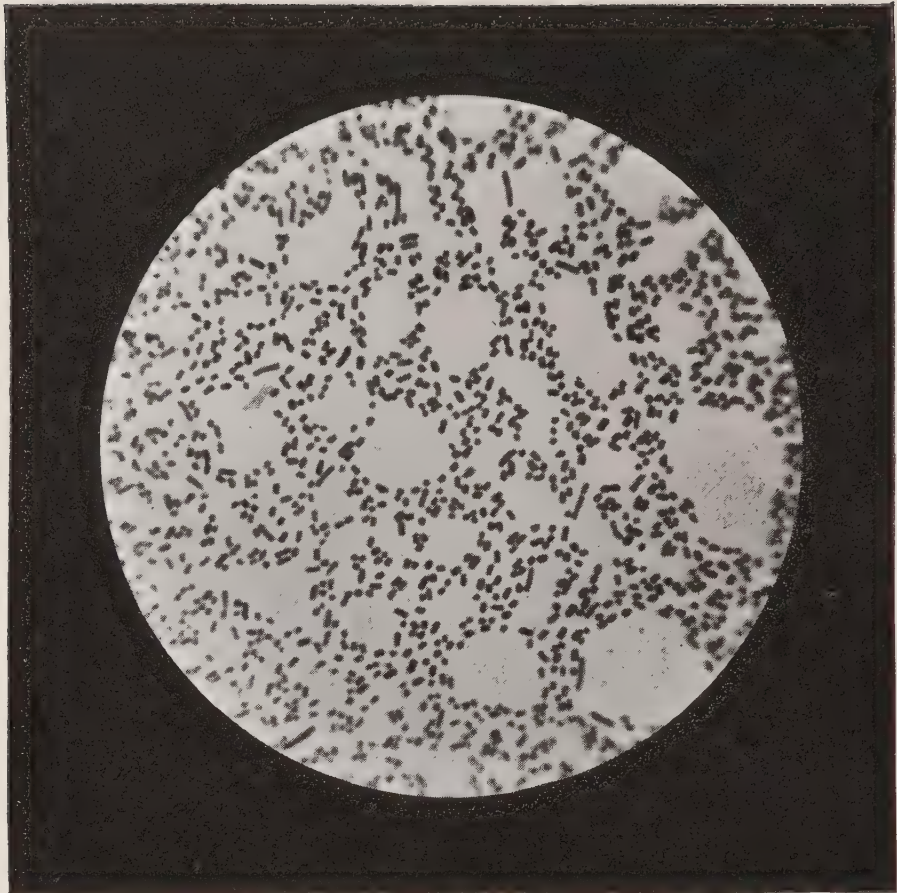


FIG. 25.



FIG. 26.

Agar cultures at 48 hours at 37° C. revealed a thick, raised, greyish shining growth, and microscopically a bacillus with rounded ends and with a trace of polarity (*see* Fig. 25). In all probability some motility also existed.

This organism proved fatal to guinea-pigs in eight days, and the same organism was observable in the tissues at the seat of inoculation (where an extensive tumefaction and necrosis existed) and in the liver in scanty numbers.

None were observed or were recovered from the spleen.

The liver cultures made from the infected guinea-pig were similar in all respects to the original human cultures. (*See* Fig. 26.)

The organism did not produce stalactitic formation in ghee-bouillon, and this fact along with its slight motility, cultural appearances, and the lesions produced, led to a revision of the provisional positive diagnosis which was originally made.

Case 2 is that of a European whose clinical history and *post-mortem* appearances gave rise to little suspicion, but microscopical appearances of the spleen were somewhat similar to those of Plague. In this instance also the abundant growth of the particular bacillus in the spleen was probably *post mortem*, but the microscopical appearances were suspicious enough to warrant animal inoculation. (*See* Figs. 21 and 22.)

From subcutaneous inoculation of a few minims of the spleen pulp a guinea-pig succumbed in 38 hours, with an extensive phlegmon and gelatinous infiltration affecting the whole surface of the abdominal wall and extending into the limbs.

The exudate showed an organism in large numbers, varying in shape from an ovoid form to a long straight bacillus. Bi-polarity of staining was present. Organisms of the same character were present in the liver and spleen, which were soft and congested, but not in the heart's blood.

The small intestines were slightly injected. No glandular enlargements were observed.

Cultures on agar incubated at 37° C. showed a profuse drab-colored growth resembling cultures from the original spleen, which microscopically consisted of short, straight rods, with a

tendency to polarity of staining with numerous threads. (See Fig. 27.)

This bacillus was found to be fairly actively motile, to curdle milk in 40 hours at 37° C., to be acid-producing in 20 hours at 37° C., to be non-liquefying and non-gas-producing and to present in anaerobic stab cultures in glycerine agar a curious ramified growth.

It was, moreover, found to be highly pathogenic for white rats and for guinea-pigs (death occurring in less than 48 hours), with an extensive phlegmon spreading from the point of inoculation.

It was not pathogenic for fowls.

The bacillus briefly described above was the source of temporary delay in diagnosis, in more than one case from its appearance in spleen smears and from its pathogenicity.

The hæmorrhagic condition of tissues described above was, however, much more extensive and severe than the condition sometimes seen in inoculations with the Plague bacillus, and whereas in the latter case organisms are, as a rule, found in great numbers in the spleen, in the former the spleen and liver contain few organisms, and no enlargement of glands is noticed.

The organism isolated from fowls (referred to above—*vide* Fig. 23), which had caused some extensive mortality in ducks, fowls, geese, and pigeons (750 in number) on premises in which Plague had also occurred, was so alike in morphology (Fig. 28) and cultural appearances (Fig. 1, *b*) to the Plague bacillus as to delay a definite pronouncement until differential points had been determined.

It was found, however, with this organism that the growth on agar appeared rather earlier at 37° C., that the growth is much less adherent to the medium, and can with ease be washed off by filling the tube with water (a phenomenon which does not occur with *Bacillus Pestis*), that the organism is more slender, that stalactitic formation does not occur, that the pathogenicity is quickly lost by artificial culture, and, moreover, is widely divergent from the pathogenicity of *Bacillus Pestis*. The latter was found to have no appreciable effect on fowls, although various



FIG. 27.



FIG. 28.

strains were used and very large quantities administered, but to be constantly fatal in ordinary laboratory doses for rodents. The former was found to have a wider range of pathogenicity—namely, birds and rodents—and even to cause severe symptoms in pigs, but its virulence rapidly decreased when cultivated artificially.

APPENDIX B.

GRANARY EXPERIMENTS.

I.

The conditions were very similar to those existing in an ordinary granary or grain store, the humidity probably being greater in the experimental granaries, water being constantly supplied and the doors kept closed.

Granary 1.—264 cubic feet. Well lighted, infected by 8 inoculated rats ; bodies left *in situ*.

On restocking four months after all were dead, the disease did not appear in the fresh rats.

Granary 2.—264 cubic feet. Light excluded. Infected by 8 inoculated rats, and bodies left *in situ*.

Restocking four months after all were dead gave a negative result.

Granary 3.—264 cubic feet. Well lighted. Infected by 8 inoculated rats, and bodies left *in situ*.

On restocking two months after all were dead, the disease did not occur in the fresh rats.

Granary 4.—264 cubic feet. Light excluded. Infected with 8 inoculated rats and bodies not removed.

On restocking two months after, the disease did not appear in the fresh rats.

Granary 5.—264 cubic feet. Well lighted. Infected with 15 inoculated rats and the bodies left.

On restocking three months after, the disease did not reappear in the fresh rats.

Granary 6.—264 cubic feet. Well lighted. Infected with 8 inoculated rats. At the time of inoculation, after careful handling and prolonged observation, only one flea was found

(*P. Pallidus*), which was removed. On the decease of all the rats, the bodies were removed, and 8 healthy rats were turned in, which had been under observation in a non-infected granary for a fortnight. At the expiration of eight days one of the fresh rats was found dead, and the examination yielded positive results, which were confirmed by cultural and re-inoculation methods.

All openings in the granary were then closed and pasted over, and the interior subjected to the action of SO_2 5·3 per cent. for 24 hours, all rats having been removed before disinfection.

On restocking with 6 fresh rats (which had been under observation for a fortnight in a non-infected granary), 1 died from Plague in seven days (a finding confirmed by cultural and re-inoculation methods), and thereafter the other rats quickly succumbed.

The interior was then exposed to the action of Formic-Aldehyde gas for 24 hours by means of an Alformant "A" lamp. All chinks were effectively closed, as no smell of the vapour could be detected.

On restocking, the disease again appeared at the expiration of nine days, and the finding was confirmed in the usual way.

On the decease of all of these rats, the box was shut up for three months and then restocked. No disease occurred in the fresh rats, although under observation for a month.

Granary 7.—264 cubic feet. Well lighted. Infected with 8 inoculated rats and bodies left *in situ*.

On restocking at the expiration of three months, no disease occurred in the fresh rats.

Granary 8.—573 cubic feet. Well lighted. Infected by 8 inoculated rats, and bodies left *in situ*.

On restocking at the expiration of one month, one rat succumbed to Plague in 12 days. (The finding was confirmed by cultural and re-inoculation methods.) SO_2 5·3 per cent. failed in this case also to disinfect the granary, as on restocking the disease reappeared in the fresh batch of rats.

Granary 9.—264 cubic feet. Light excluded. Infected with 8 inoculated rats, and bodies left *in situ*.

On restocking at the expiration of three months, no disease occurred in the fresh rats.

Granary 10.—Used as control box for keeping store of healthy rats. No epizootic took place in this box, and the animals thrived if kept well supplied with food, water, and bedding.

II.

A large number of *post-mortem* examinations of rats had necessarily to be undertaken for confirmatory purposes, and the most noticeable point was that certain lesions, such as enlargement and engorgement of spleen and liver, presence of glandular enlargements with periadenitis, either in axillæ, groins, or mesentery, were more often absent than present. For purposes of comparison a number of healthy rats were examined, and measurements made of the spleen. Little difference was found to exist between the organs of these and of Plague-stricken rats.

Glandular enlargements were found to be rare, even in inoculated rats.

These observations are also borne out by notes on a large number of routine *post-mortem* examinations on rats during the course of the epidemic.

In two instances in subcutaneously inoculated rats the principal seat of the disease was in the lungs, which were carnified and crowded with typical organisms (pure cultures being obtained), while the spleen and liver contained the bacilli in scanty numbers.

The *post-mortem* appearances noted in guinea-pigs vary considerably from those in rats.

The speckled spleen is generally not observed in those animals which have succumbed within three days of inoculation, as is generally the case when using young animals.

Local reaction, if inoculation is subcutaneous, is generally severe, and the nearest lymphatic glands usually show periadenitis with punctiform hæmorrhages. A common feature is the presence of some amount of gelatinous infiltration of the subcutaneous tissues extending far beyond the point of inoculation.

Both lungs usually show patchy congestion.

White rats show similar lesions to brown and black rats.

APPENDIX C.

DETAILS OF ANIMAL EXPERIMENTS.

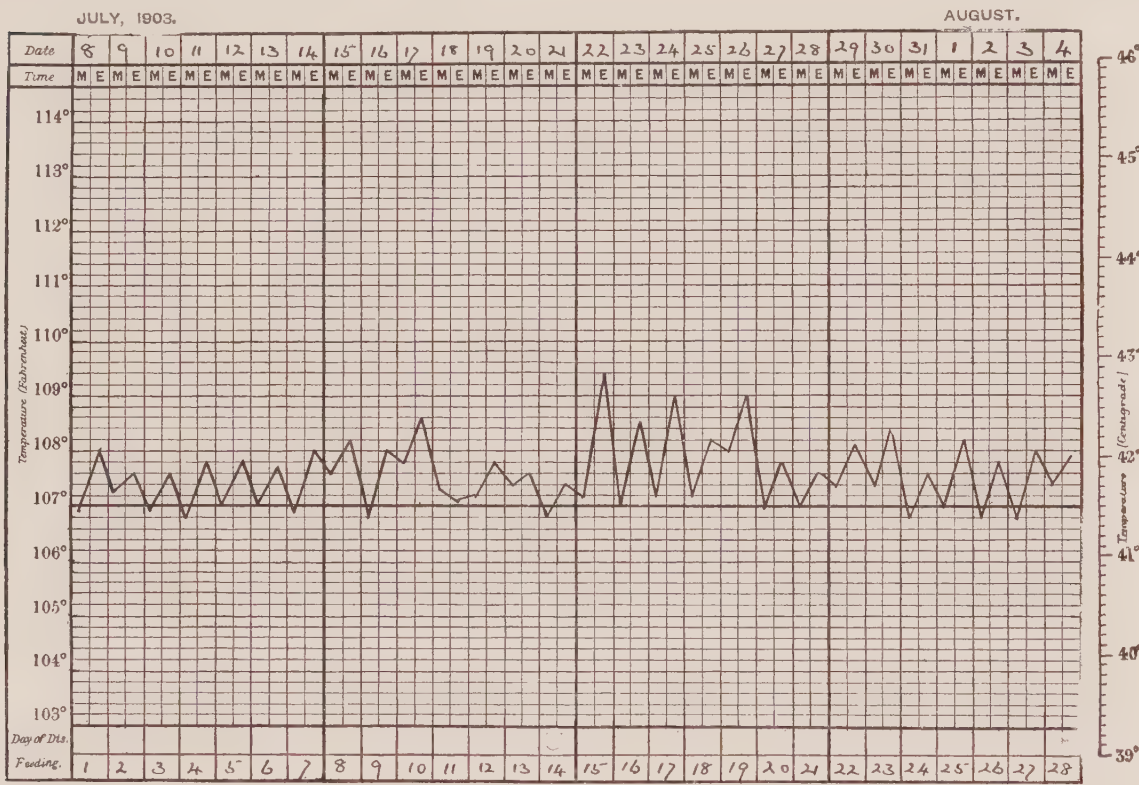
I.—FOWLS.

THE feeding and subsequent treatment of 20 fowls were carried out in the following manner :—

The organs of recently dead rats which had previously been inoculated with the *Bacillus Pestis* (and placed in one of the experimental granaries before described), were finely minced,

PESTIS.

Fowls.—Control. Weight on admission, 1,360 grns. Weight on discharge, 1,473 grns.



mixed with rice grains, and placed in a large glass bowl. The bird was then gently held between the hands within reach of the bowl. In all cases the fowl ate greedily. The portions of the rat used for feeding were the spleen, liver, lungs, kidneys, heart, and buboes if any existed. The intestines were as a rule rejected. Each fowl generally ate approximately one-half the organs of a full-grown rat, although, as mentioned hereafter, in some cases a fowl was given the whole of the organs. The beak

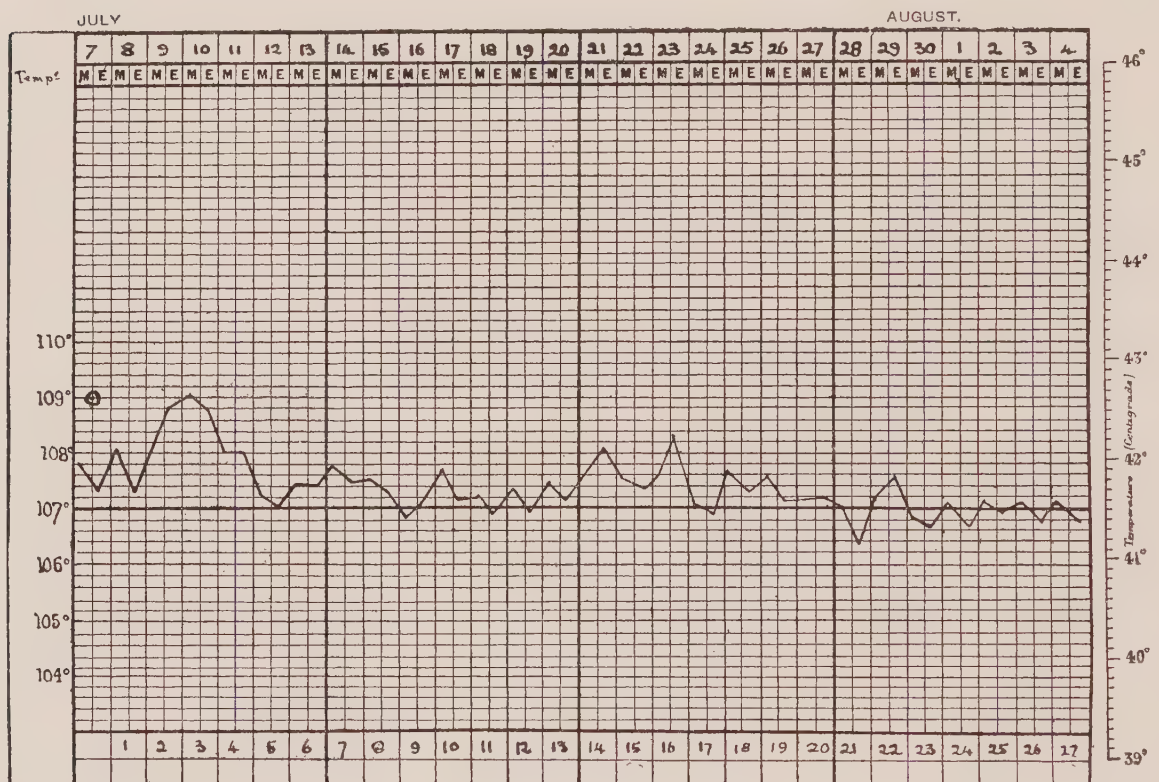
was then wiped with a disinfecting cloth, and the bird placed in a zinc-lined cage which stood over a large tray of disinfectant.

Control animals were inoculated, and the rat tissues were not used for feeding purposes unless found to contain large numbers of typical plague organisms.

Fowls 1 to 6 were fed and inoculated with the finely-minced organs of rats recently dead. The fluid part of the mixture

PESTIS.

Fowls. Case I.—Black Hen, grey neck. Weight on admission, 1,484 grns. ♂ Fed on July 7, 1903, with organs of Plague-stricken Rat. Excreta of this fowl inoculated, on July 24, into Guinea-pig G559. Under observation until October 12, 1903. Hen-pecked by other birds. Weight on discharge, 1,371 grns.



contained large numbers of organisms, *vide* microphotograph of smear (Fig. 29), Section III.

Cultures on agar turned out to be typical both microscopically and macroscopically.

A control guinea-pig inoculated subcutaneously with three minims of the exudate at the same time died in three days, with a hæmorrhagic condition of the groin glands and a finely mottled spleen, that contained large numbers of typical organisms.

Cultures from the latter also proved in every way typical.

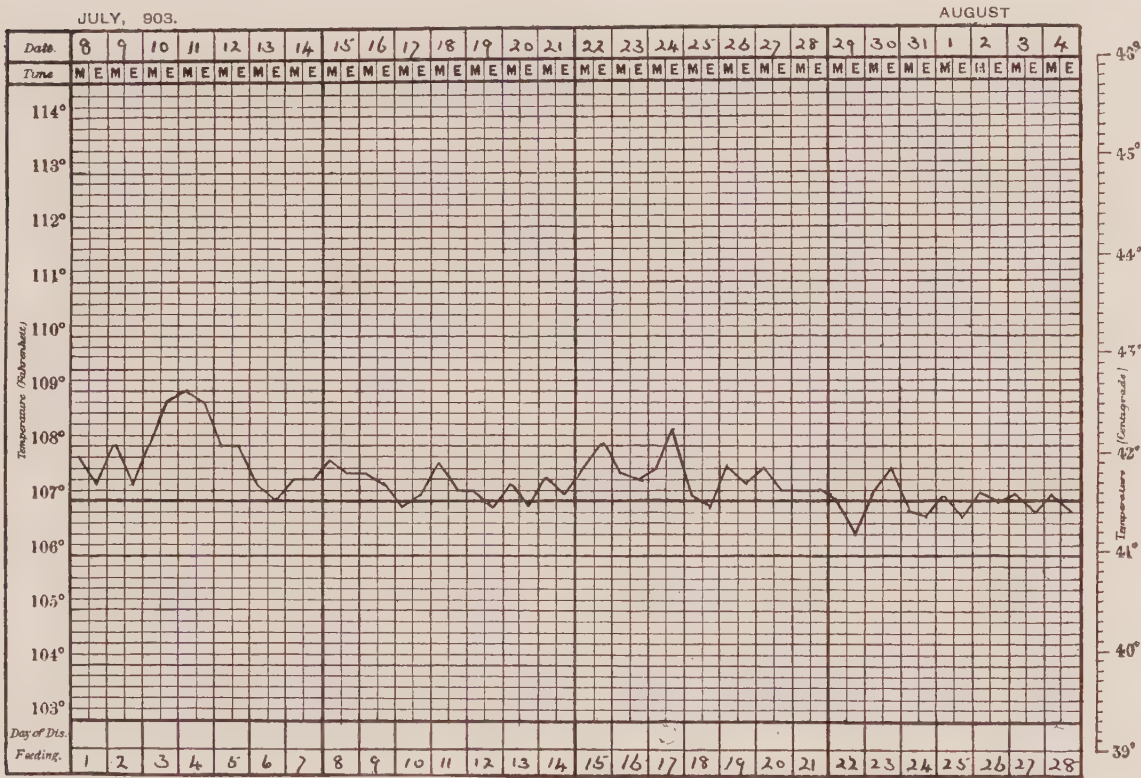
Fowl 1.—Under observation four days before the experiment.

Fed on July 7th with organs of recently dead rats, which four days previously had been inoculated with *Bacillus Pestis*.

No signs of illness whatever were noticed, although the bird was under daily observation till October 12th, a period of 97 days. The comb remained bright pink in colour, the stools constantly normal ; the fowl gained weight.

PESTIS.

Fowls. Case II.—Black Hen, grey neck. Weight on admission, 1,484 grns. Fed, July 7, 1903, with organs of Plague-stricken Rat. Excreta of this fowl inoculated July 24, into Guinea-pig G559. Weight on discharge, 1,371 grns. Under observation until October 12, 1903. N.B.—This bird was badly hen-pecked by other fowls in same cage.



The excreta failed to induce Plague when introduced subcutaneously into guinea-pigs.

Fowl 2. Under observation four days before the experiment. Fed on July 7th with organs of rats inoculated four days previously with *Bacillus Pestis*.

No signs of illness observed at any time up to October 12th, when the bird passed out of observation. Comb remained bright pink in colour, and stools were constantly normal, and when small quantities were injected into guinea-pigs only a local swelling resulted. The fowl gained weight, and laid five eggs in captivity.

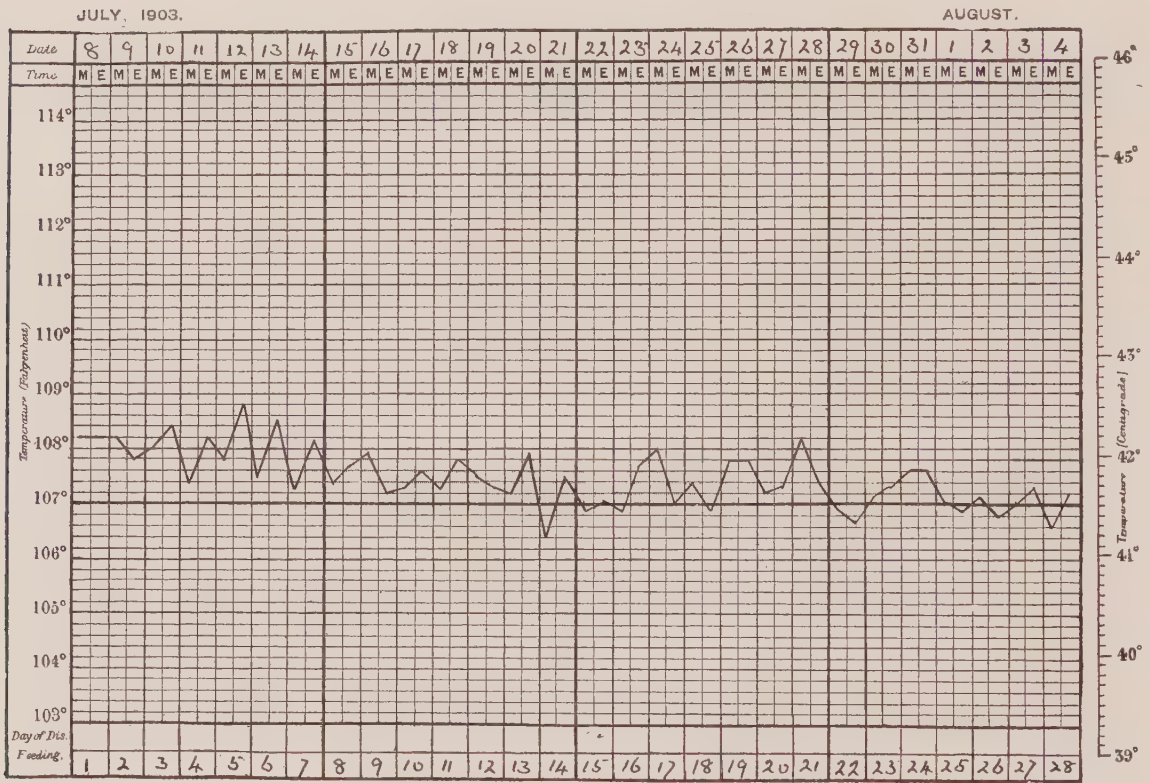
Fowl 3.—Fed on July 7th with organs of rats which were previously inoculated with *Bacillus Pestis*.

No indisposition resulted, the comb remained bright pink, the stools were constantly normal in appearance, and failed to induce plague when injected subcutaneously into guinea-pigs.

This fowl remained perfectly well, and gained in weight till it passed out of observation on October 12th.

PESTIS.

Fowls. Case III.—Grey Hen. Weight on admission, 1,247 grns. Fed, July 7, 1903, with organs of Plague-stricken Rat. Excreta inoculated in Guinea-pig 560 on July 24. Weight on discharge, 1,360 grns. Under observation until October 12.



Fowl 4.—Inoculated subcutaneously in the flank with 2 c.c. emulsion of organs of rat recently dead which had previously been inoculated with *Bacillus Pestis*. The emulsion contained large numbers of the organism.

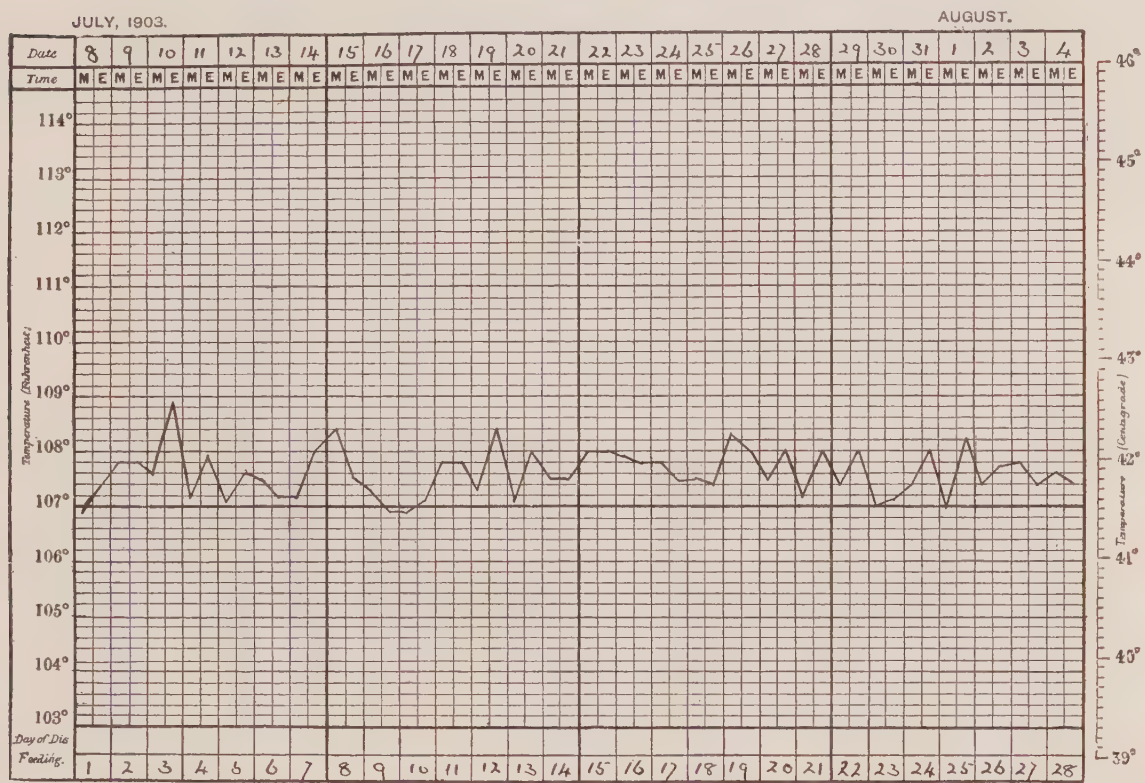
No signs of illness resulted till October 4th, when observations ceased.

Fowl 5.—Inoculated subcutaneously in the flank with 2 c.c. of an emulsion of the liver and spleen of a rat recently dead of Plague.

The fowl was under observation for three months, but no indisposition was observed.

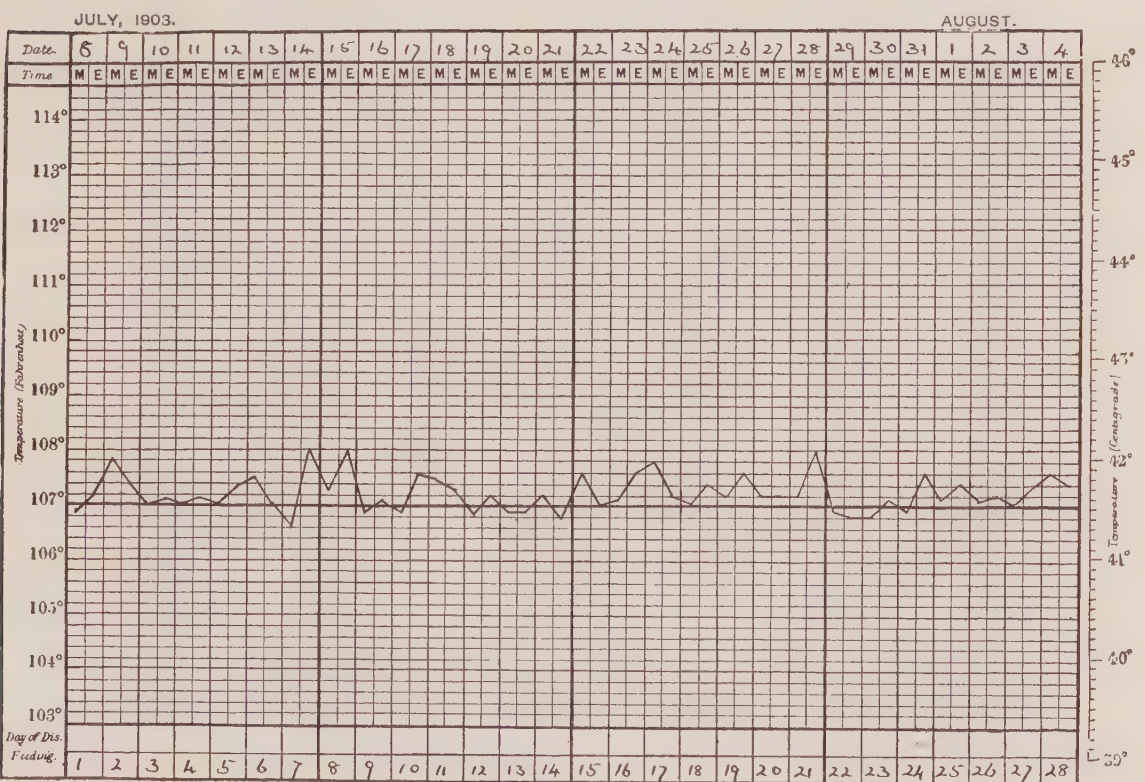
PESTIS.

Fowls. Case IV.—Young Cock. Weight on admission, 1,484 grns. Inoculated, July 7, subcutaneously with 5 c.c. emulsion of liver and spleen of Plague-stricken Rat. Weight on discharge, 1,710 grns. Under observation until October 4, 1903.



PESTIS.

Fowls. Case V.—Young Cock. Weight on admission, 1,484 grns. Inoculated, July 7, 2 c.c. emulsion of organs of Rat. Weight on discharge, 1,597 grns. Under observation until October 4, 1903.



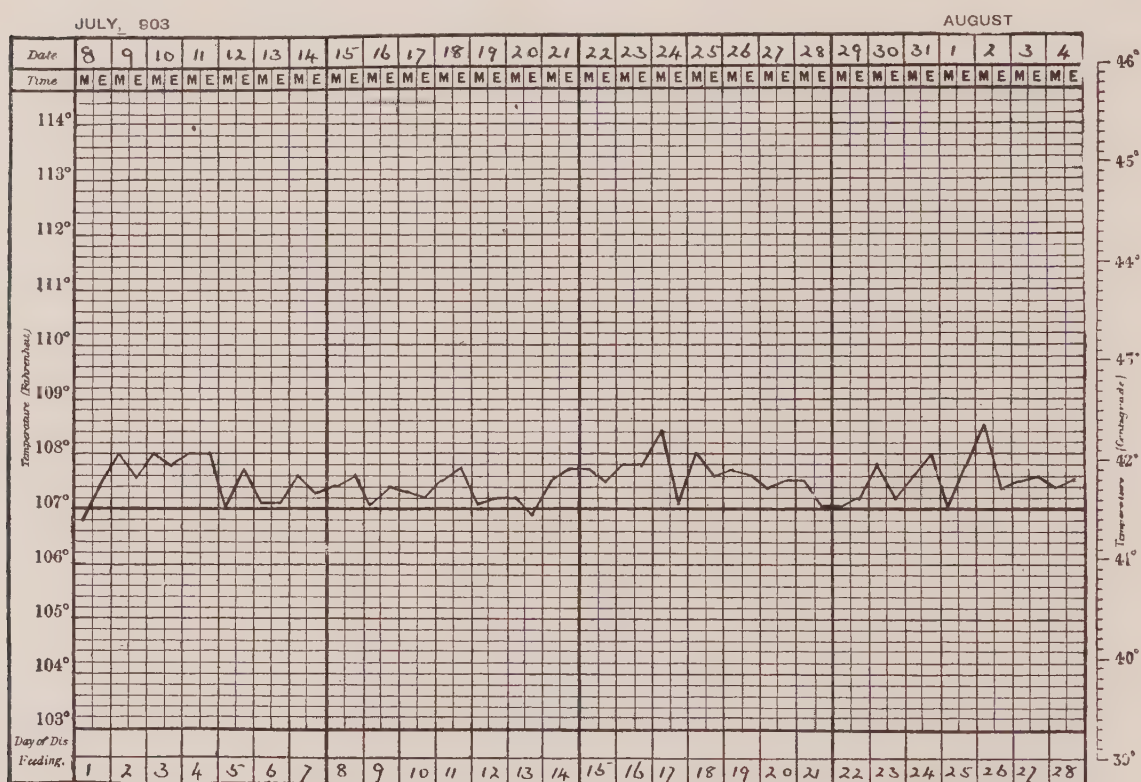
Fowl 6.—Inoculated in the flank on July 8th with 2 c.c. of an emulsion of the organs of recently dead rats, which had previously been inoculated with *Bacillus Pestis*.

No illness whatever resulted in a period of three months.

Fowls 7, 8, 9, 10 (4 cocks) were fed on August 16th, each separately, with the finely cut up organs of rats which had previously been inoculated with Plague. The rats were freshly

PESTIS.

Fowls. Case VI.—Black Cock. Weight on admission, 1,360 grns. Inoculated, July 7, 2 c.c. emulsion of organs of Plague Rat. Weight on discharge, 1,700 grns. Under observation until October 4, 1903.



dead, and the material contained large numbers of typical organisms (see Fig. 30).

Cultures proved macroscopically and microscopically typical and highly pathogenic for rats and guinea-pigs.

Emulsion of the excreta of fowls 7 and 9 taken 48 hours after feeding only produced a temporary indisposition in guinea-pigs.

The fowls remained perfectly well from the day of feeding to November 30th, when observations were discontinued.

The combs were bright pink in colour, and stools were never observed to be otherwise than normal.

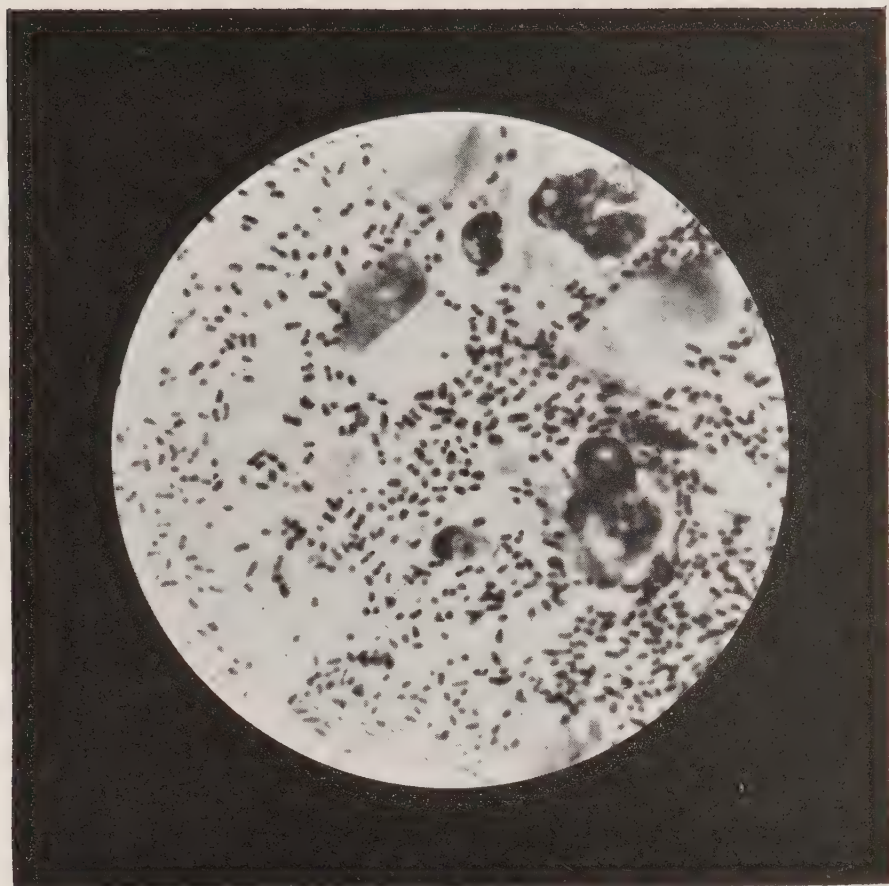


FIG. 30.

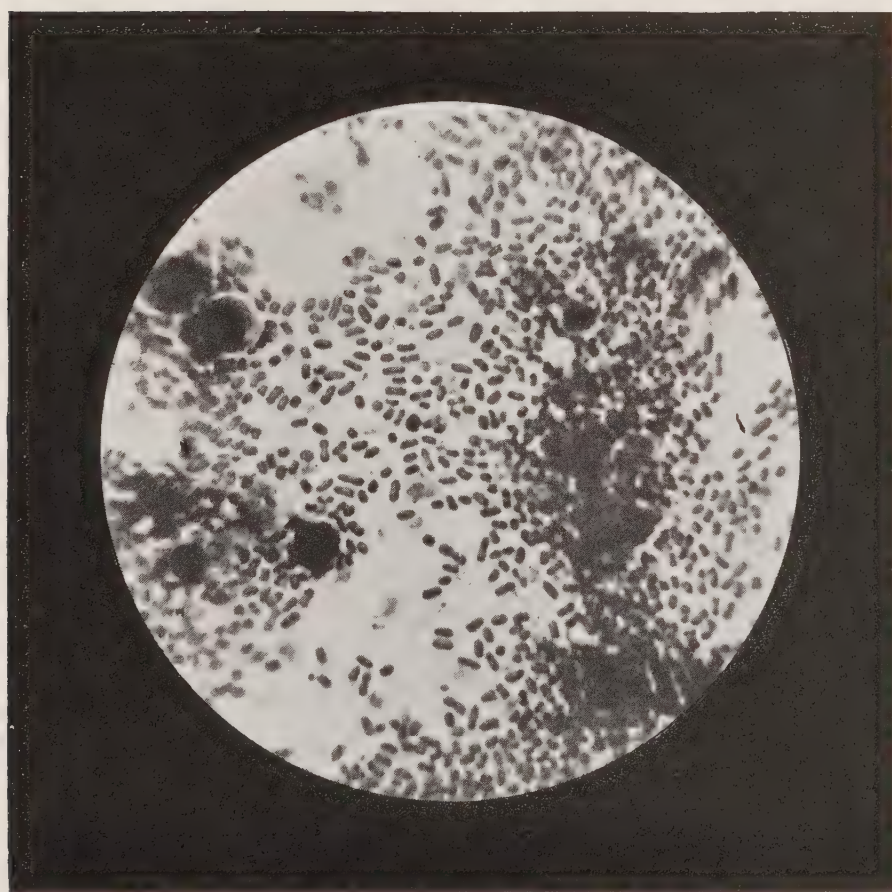


FIG. 31.

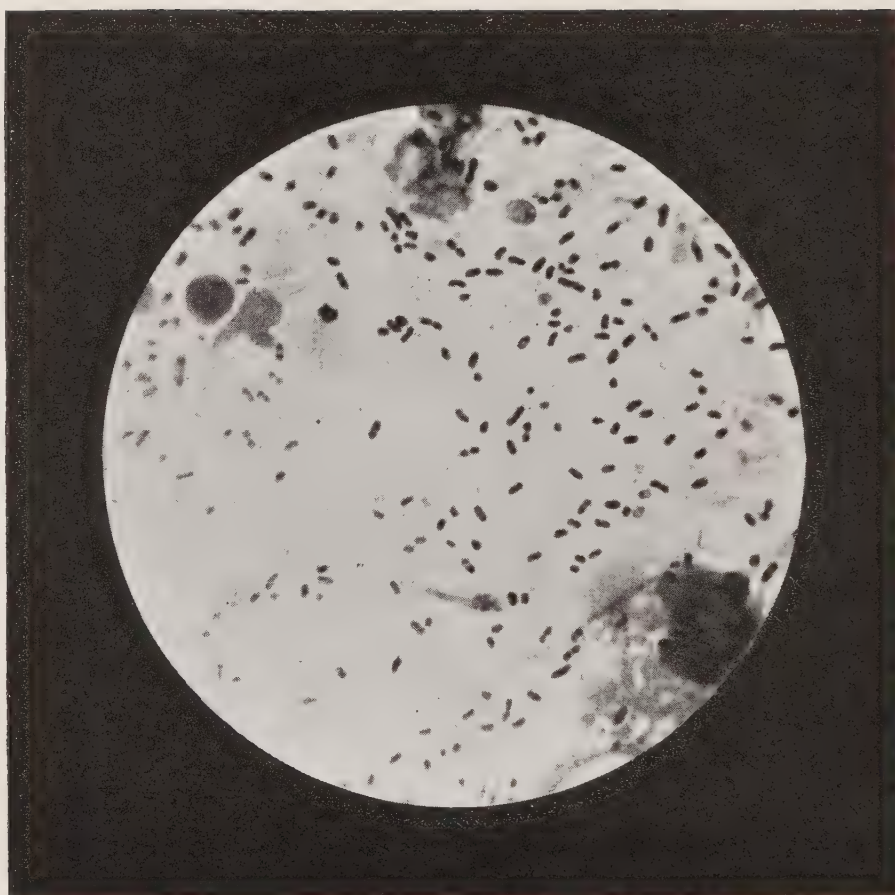


FIG. 32.

Face p. 143.

Fowls 11, 12, 13, 14, and 15 (3 cocks and 2 hens) were separately fed on the organs of rats recently dead, which had previously been inoculated with *Bacillus Pestis*.

The material contained great numbers of organisms (Fig. 31), cultures on agar proved typical and virulent for guinea-pigs.

The excreta of Fowl 12 and Fowl 15 were collected 48 hours after feeding, and inoculated into two guinea-pigs. The latter showed only a local inflammation at the point of inoculation, which subsided without suppuration.

No indisposition whatever was subsequently noticed in the fowls. Several eggs were laid by the hens. Daily observations ceased on October 30th, when all seemed in better condition than at the beginning of the experiment.

Fowls 16, 17, 18, 19, and 20 (3 hens and 2 cocks) were separately fed on August 21st on the fresh organs of rats which had previously been inoculated with *Bacillus Pestis*. The material contained the typical bacillus in large quantities (Fig. 32).

Cultures proved typical and virulent for guinea-pigs. No indisposition was noticed, and on August 24th they were separately fed with the minced organs of a large guinea-pig, which had previously been inoculated with another strain of *Bacillus Pestis*. On September 1st Fowl 16 laid one egg.

On September 4th each fowl was again separately fed on the organs of another guinea-pig which had been inoculated for the purpose. On September 5th Fowl 16 laid an egg, and thereafter for some time laid on every alternate day.

On October 4th Fowls 16 and 17 ate the liver, spleen, lungs, heart, and buboes of a guinea-pig which had been inoculated for the purpose, and which had died with the speckled spleen, hæmorrhagic glands and other typical appearances of Plague. The organs were crowded with bacilli, and cultures turned out to be also typical.

No indisposition resulted, and on the next day both laid eggs, and continued to lay daily or on alternate days for a fortnight.

For three successive days after feeding with the Plague material, on October 4th, excreta was carefully obtained from

each fowl * emulsified in bouillon and injected subcutaneously into guinea-pigs. Some local inflammation at the point of inoculation and a slight rise of temperature for two days also resulted and the 6 guinea-pigs were eventually discharged well.

Fowls 16 and 17, which had thus received on four occasions large quantities of highly-infective material, as well as Fowls 18, 19, and 20, which had received infective material on three occasions, remained perfectly well, and gained weight under treatment.

The combs of all remained bright pink, the eyes bright, and the stools constantly normal. Observations were discontinued on December 10th.

II.—PIGS.

Pig 1.—Black Berkshire, 4 months old, and under observation five days before the experiment, was drenched on September 8th by means of a flexible canula with 100 c.c. of an emulsion of the liver, lungs, spleen, heart, kidneys, and bubo of a full-grown rat, which had been previously inoculated with *Bacillus Pestis*. The emulsion contained large numbers of the typical organism, *vide* microphotograph No. 33.

Considerable difficulty was experienced in passing the canula, and some force was eventually exerted. The operation caused considerable embarrassment of respiration, so much so that it was suggested at the time that the canula had entered the trachea. The emulsion was quickly administered; a streak of blood was observed on the end of the instrument. Immediately after release the pig suffered from dyspnœa, and showed alarming symptoms for about half an hour. Next day, however, he was much better, and remained so for three days. On September 12th respiratory symptoms reappeared; the breathing was labored, and moist rales could distinctly be heard.

This state continued till September 15th, when the pig began

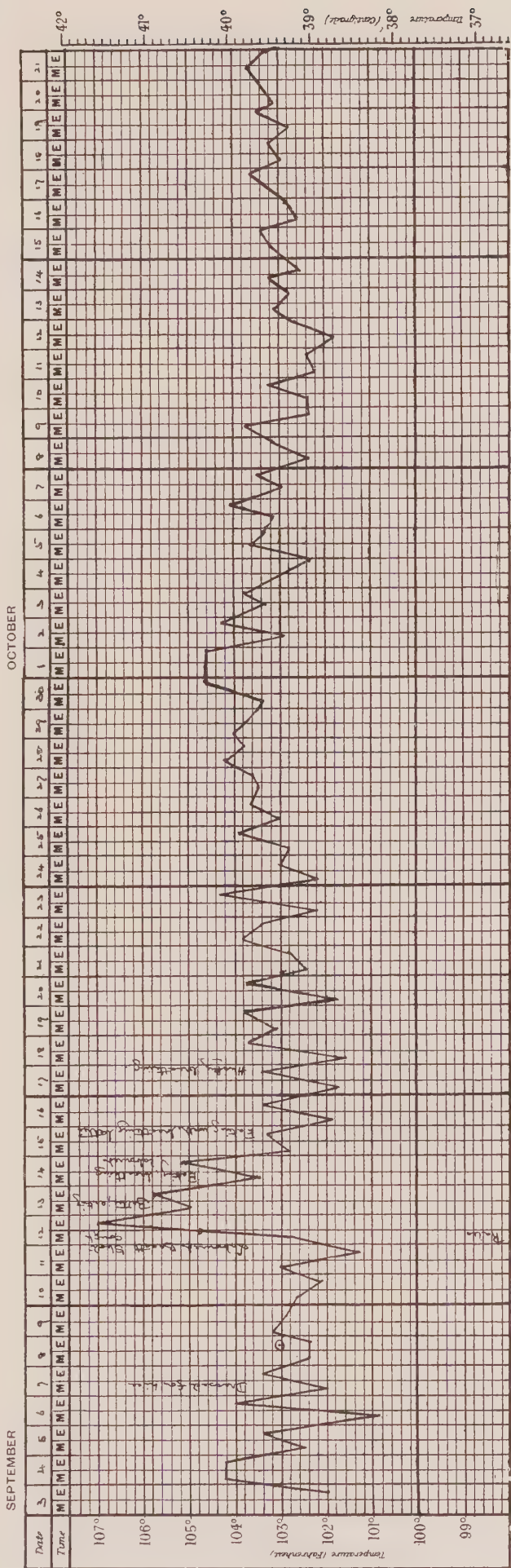
* On taking the temperature in the rectum, in many cases excreta can be withdrawn with the bulb of the thermometer.



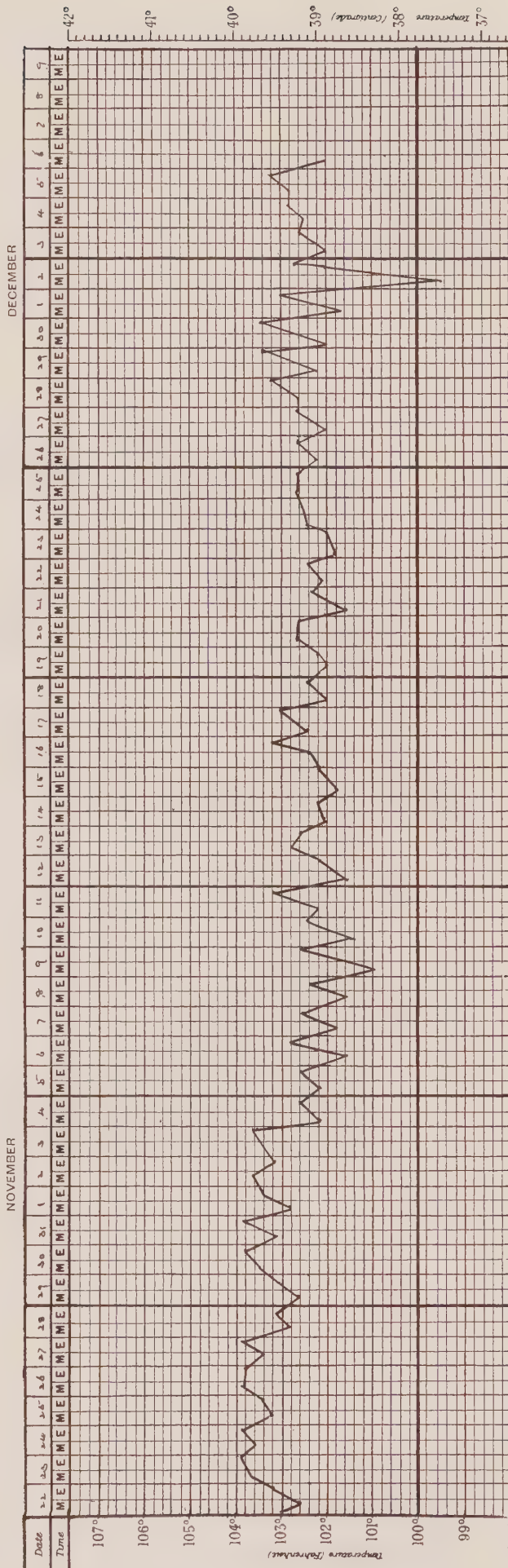
FIG. 33.

Face p. 144.

SEPTEMBER



DECEMBER



to feed well, and the breathing gradually returned to normal. Glandular enlargements were searched for daily, but none occurred.

On September 14th some clear viscid mucus, of which there was a considerable discharge, was collected from the nasal passages, and .5 c.c. inoculated subcutaneously into a guinea-pig. On September 18th the guinea-pig died, and the *post-mortem* examination revealed the fact that death was due to Plague (*vide* Microphotograph 34). This finding was carefully confirmed by observation of the spleen cultures, stalactitic growth and re-inoculation into a guinea-pig with subsequent culture. All methods, however, proved positive. The Plague bacillus was also recovered by plating the pig's nasal discharge, and the resulting growths were subjected to the same tests.

Pig 1 remained well, and thereafter rapidly gained weight and condition.

It is, however, more than probable that the whole or part of the infective material was poured into the trachea or one of the larger bronchi.

Sixteen days after the administration of the material an attempt was made to again isolate the bacillus from the nasal discharge, which was by this time very scanty. The attempt failed, and Plague could not be induced in guinea-pigs by subcutaneous inoculation of the nasal defluxion.

The pig is still under observation on January 10th, but is improving in condition, and is in perfect health.

During the time of his illness, other pigs in the same styre were in close contact, but none showed a rise of temperature or indisposition, and a systematic attempt to isolate the bacillus from their nasal secretions failed.

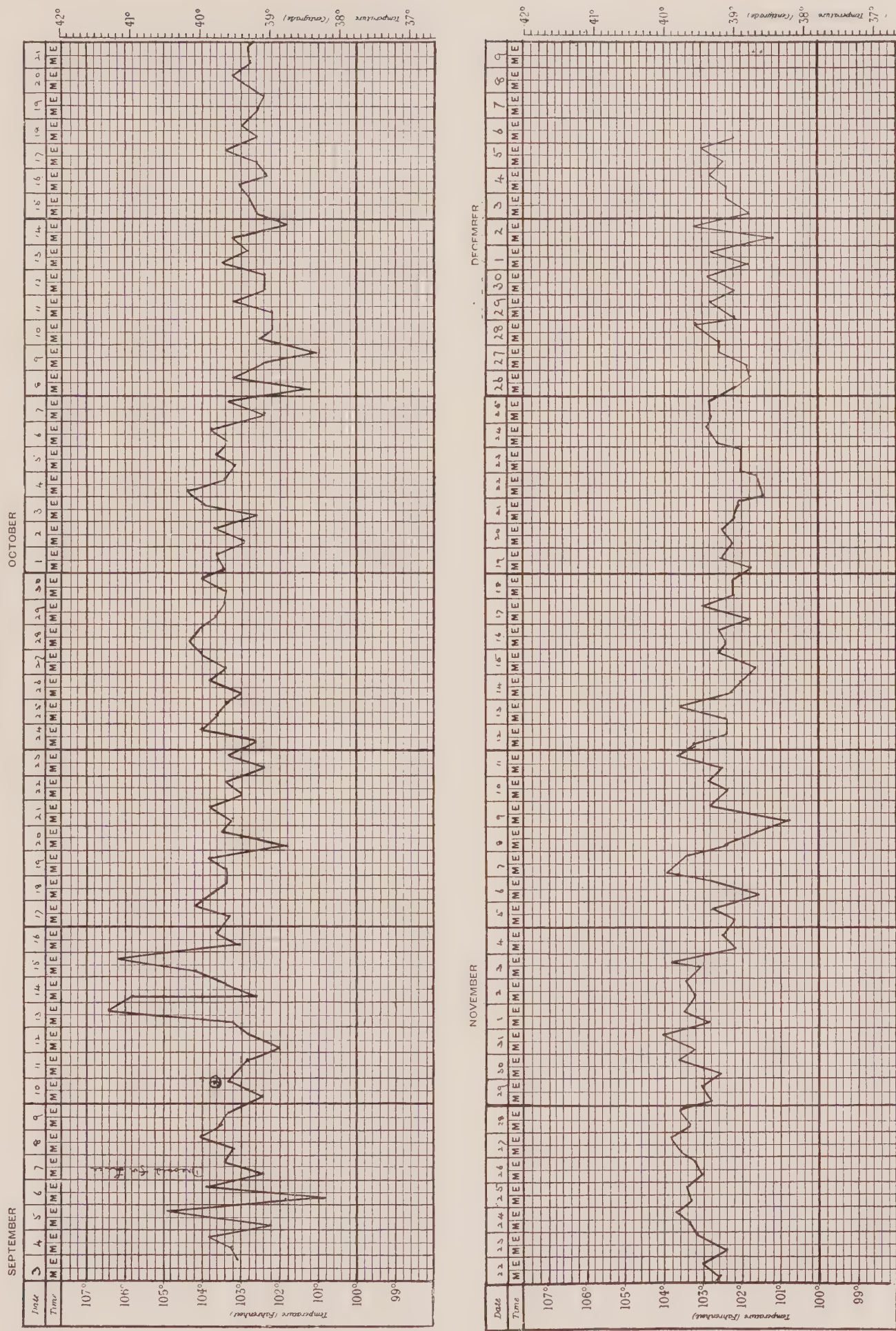
Pig 2.—Black Berkshire, 4 months old, was fed on September 10th with an emulsion of the organs of a rat which had been inoculated with *Bacillus Pestis*. The organs were crushed in a mortar, and soaked in 50 c.c. bouillon for half an hour. Large numbers of organisms were present, and cultures made at the time proved positive morphologically and pathogenic for guinea-pigs.



FIG. 34.

Face p. 146.

Fig. Number 2. This Chart shows Lengthy Normal Record subsequent to Infection. © Received 50 c.c. Emulsion Organs, Rat 2, Box 6 (Rich Granary Record).



Except the transient rise of temperature, no ill-result whatever followed. Glandular enlargements were searched for daily, but none were discovered.

On January 10th the pig is still under daily observation, and is in prime condition.

Pig 3.—Black Berkshire, 5 months old, was fed on September 30th with an emulsion of the organs of a guinea-pig which had previously been inoculated with *Bacillus Pestis*, and which had died in 110 hours with all the appearances of Plague. Cultures of the spleen proved typical and virulent for rats, and positive as regards stalactitic formation.

Beyond a temporary rise of temperature, no ill effects were noticed, although the animal was under close observation. He ate greedily, and was as bright and lively as the control pigs. Twenty-four and 48 hours after feeding, the excreta was carefully obtained, and a small quantity emulsified in bouillon and injected into guinea-pigs. Local reaction was well marked in each case, but both recovered after indisposition lasting three days.

On January 10th the pig is fattening and in perfect health.

Pig 4.—Black Berkshire, about 6 months old, was on November 9th scarified by means of a scalpel on the right flank over an area 1 inch in diameter, and with a wooden rod the spleen pulp of a guinea-pig which had been inoculated for the purpose with *Bacillus Pestis* was well rubbed in. This guinea-pig had died with hæmorrhagic groin glands and a speckled spleen containing a large number of typical organisms. Cultures proved subsequently positive morphologically, and were virulent for rats.

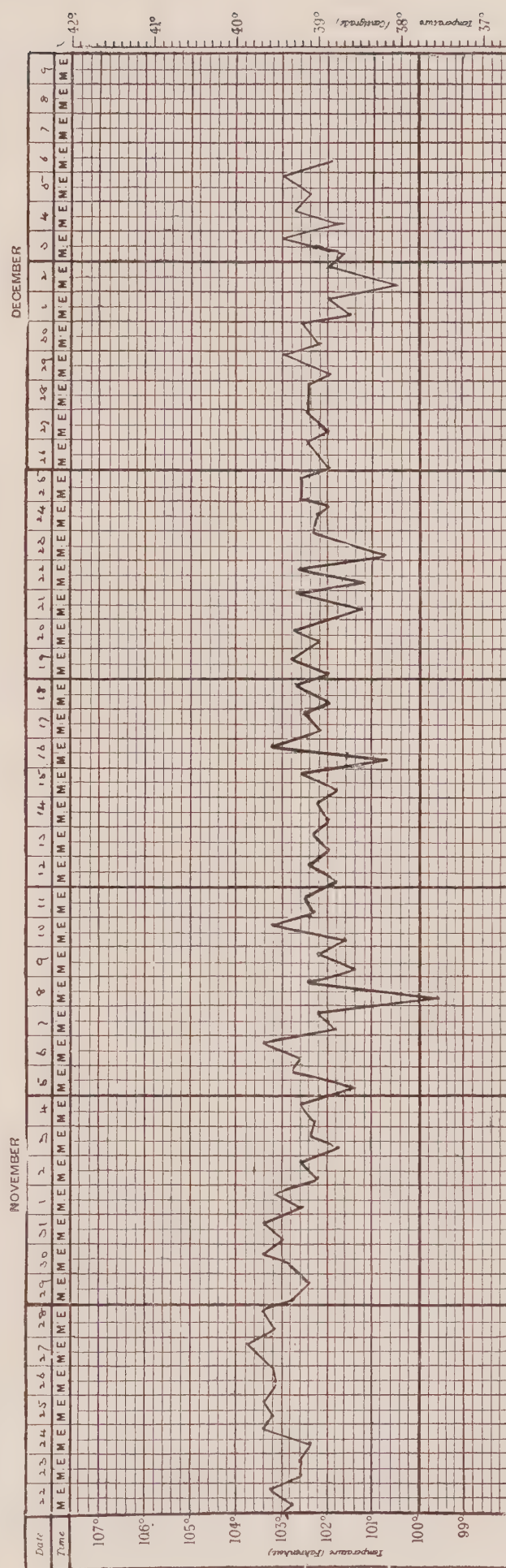
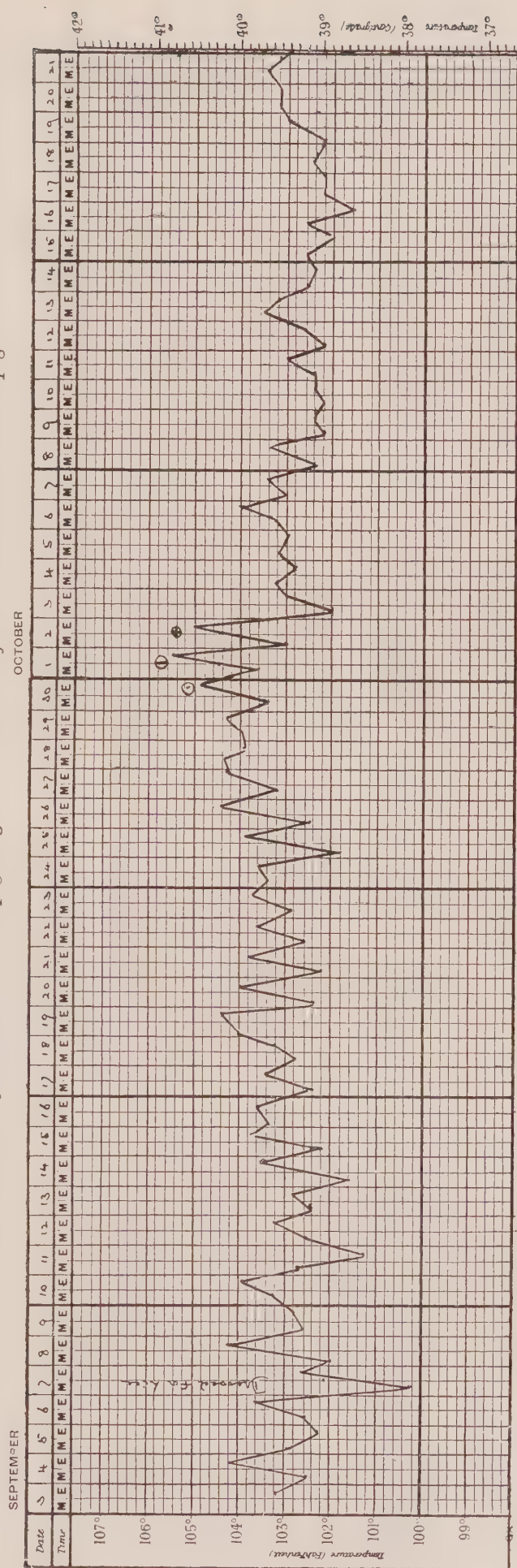
Every care was taken to make the vaccination effective, and the abraded surface was covered with dry cotton-wool over which were pasted many layers of collodion.

On the third day a tense glazed appearance was observed around the area of scarification, and on the fourth day some tumefaction, which was not apparently tender.

No glandular enlargements were discoverable at any time, and the pig showed no signs of illness. He was particularly keen

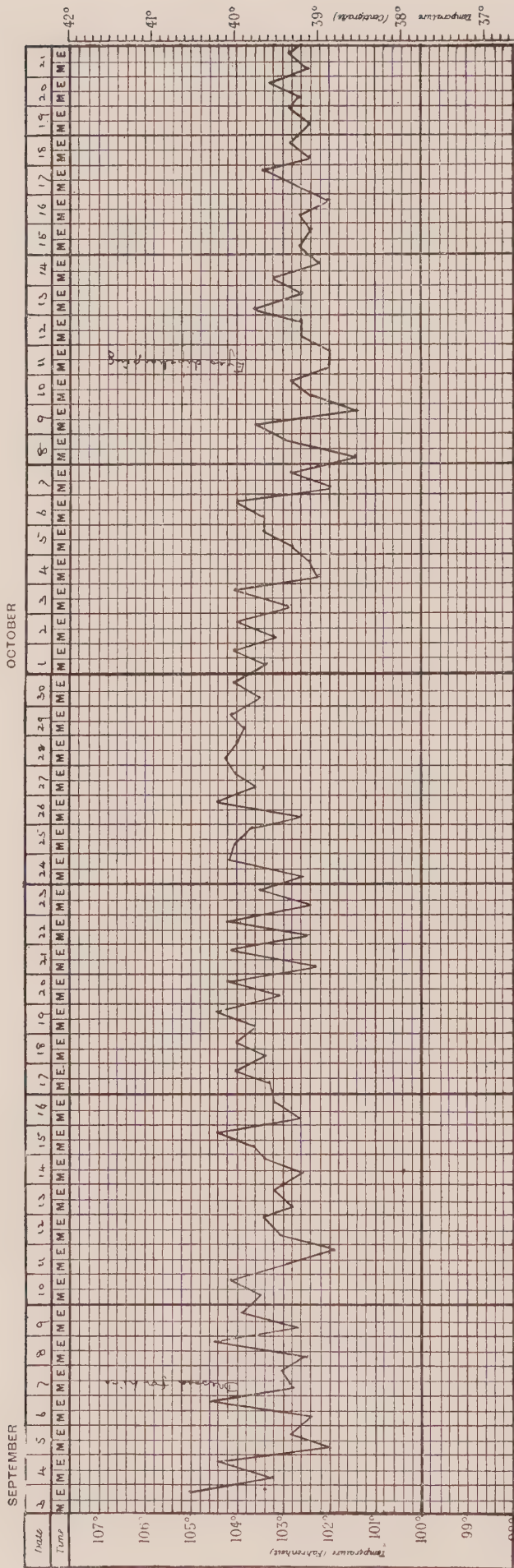
PESTIS.

Fig. Number 3. Chart showing Lengthy Record, before and after Injection. ☉ Drank Emulsion of Organs from Guinea-pig 610. ☉ Excreta Injected into Guinea-pig 613. ⊕ Excreta Injected into another Guinea-pig.



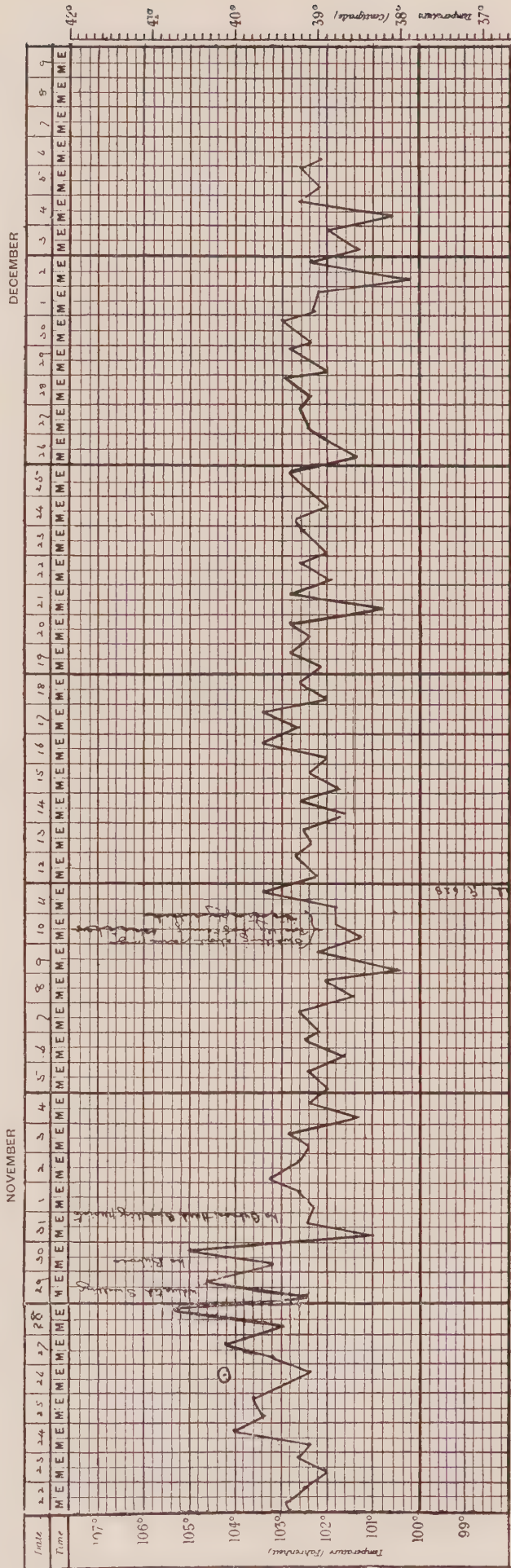
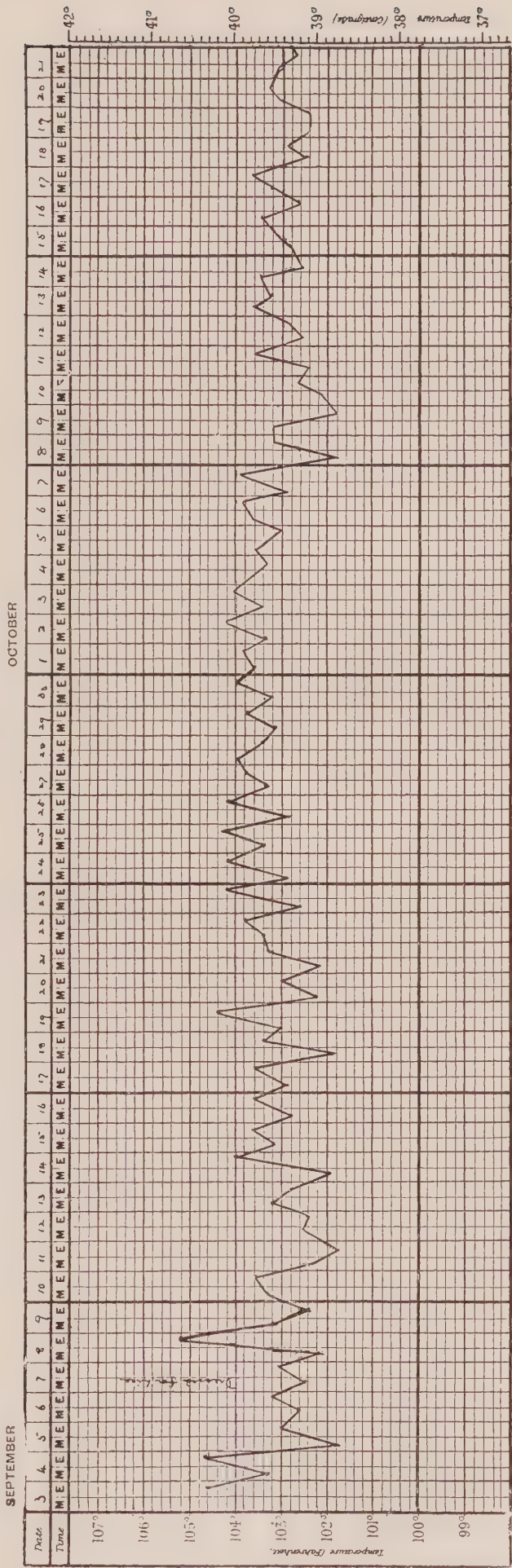
PESTIS.

Pig. Number 4. November 9, 1903, ☉ Scarified, and Spleen of Guinea-pig rubbed in.



PESTIS.

Pig. Number 5. Chart showing Lengthy Normal Record, during which time the Animal remained in Contact with Infected Pigs.
○ October 26. Inoculated in the Flank subcutaneously with 6-day Agar Culture.



on the approach of food, and no difference could be observed between his condition and that of the control pigs.

On the fifth day the tumefaction increased, but thereafter it rapidly subsided, the abraded surface healing. On January 10th the pig is fattening.

Pig 5.—Black Berkshire, about 6 months old, was on the 26th October inoculated in the right flank with an emulsion of the whole of a six-day agar culture of *Bacillus Pestis*. (Simultaneously a white rat was inoculated with a trace of the same culture as a control, the latter dying with typical appearances. Culture of the spleen proved confirmatory.)

On the third day following the inoculation there was a patch of induration 2 inches in diameter at the point of inoculation not noticeable to the eye, but palpable and tender. The pig ate well, but seemed not quite so lively as the control pigs. On the following day, however, he seemed quite himself again, and ate greedily. The patch of induration was no longer tender, but was more raised, and apparently itched. Thereafter the pig enjoyed excellent health, and improved in weight and condition, although the swelling increased in elevation, and remained for a fortnight, when some fluctuation could be made out.

Two days afterwards the abscess pointed and burst.

An attempt was made both by plating and by animal inoculation to recover the Plague *Bacillus* from the discharge, but failed.

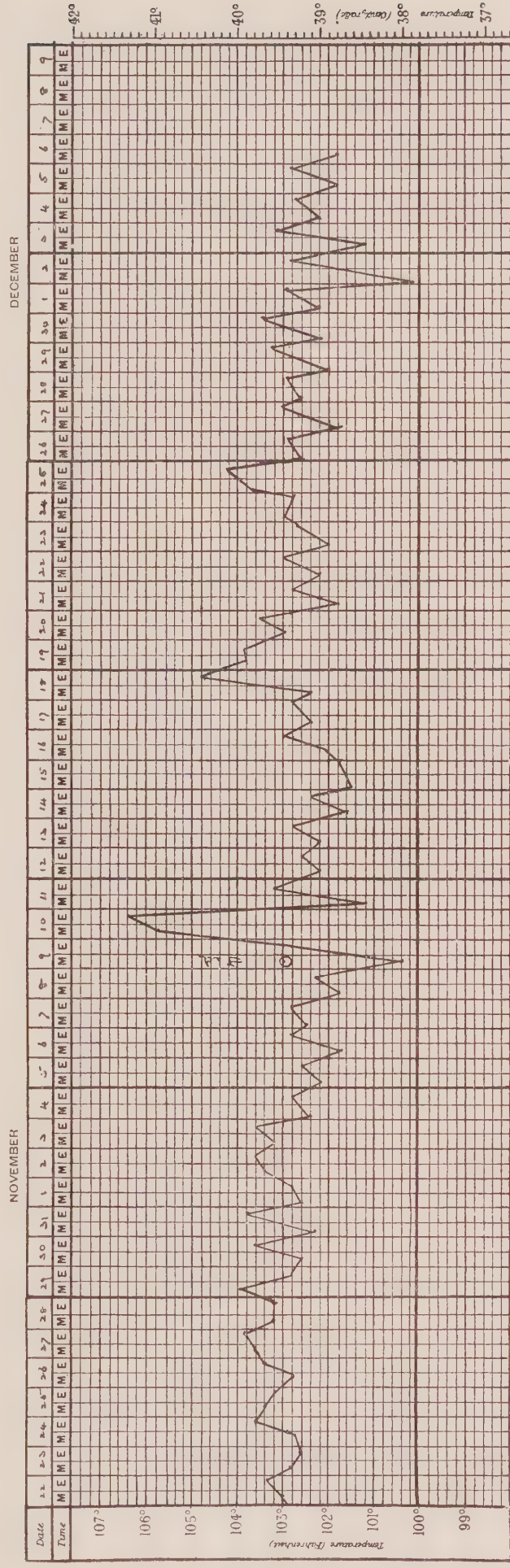
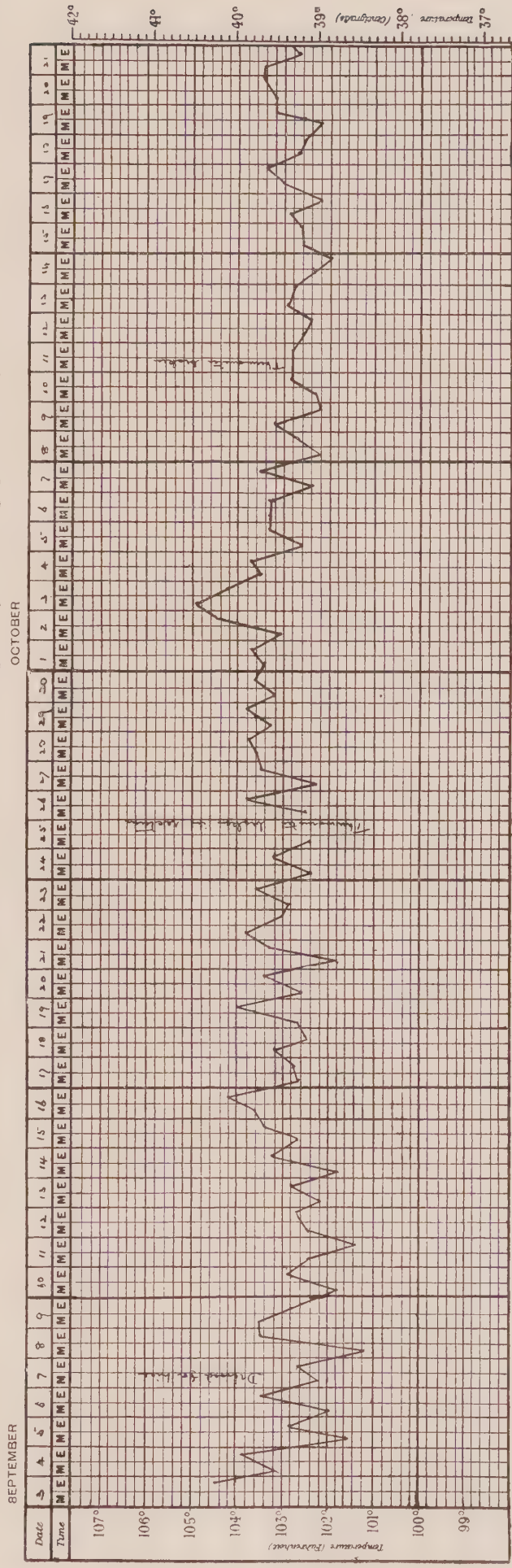
Small sloughs and thick yellow pus discharged for some days. The health of the pig seemed not to be materially deranged at any time, and a fortnight after inoculation was approximately equal in weight to the control pigs.

Daily palpations were made to discover glandular enlargements in the axilla or groins, but none were made out.

On January 10th, 1904, the pig is still in good condition.

Pig 6.—Black Berkshire, about 6 months old, ate greedily on November 9th, the liver, lungs, spleen, heart, kidneys, intestines, and abdominal walls with hæmorrhagic groin-glands of a full-grown guinea-pig, which had been infected with Plague, and died in four days with the classical appearances.

Pig. Number 6. This Chart shows a Lengthy Normal Record, during which time the Animal remained in Contact with Infected Pigs.



The cultures of the spleen proved confirmatory and virulent.

This pig at no time lost appetite or showed any signs of illness or glandular enlargements, although the temperature rose to 105.7° F. the day after feeding. Thereafter the chart of this pig is similar to foregoing charts.

On January 10th the pig is in normal health and fattening.

Pig 7.—White, of an inferior type, known as Kaffir pig, about 4 months old, having shown a normal temperature for 5 days. The pig ate the liver, lungs, spleen, heart, kidneys, intestinal walls with hæmorrhagic glands of two full-grown guinea-pigs, which had died in three days with typical appearances from the inoculation of a few minims of spleen pulp of a native who had died of Plague. With this material was placed portions of the spleen, liver, and lungs from a case of Plague. It was desired to ascertain whether the administration of such a large bulk of infective material would cause any appreciable difference in the result obtained in former experiments. These tissues, mashed in a large bowl with a sprinkling of crushed maize, were eagerly eaten. The snout was then wiped with a cloth wrung out of disinfectant solution, and the animal kept under the closest surveillance.

The temperature rose to 106.2° F. on the third day, and on the succeeding day the pig was not quite so lively as the control pigs, but yet ate well. He brightened up on the fourth day, and thereafter seemed in excellent health.

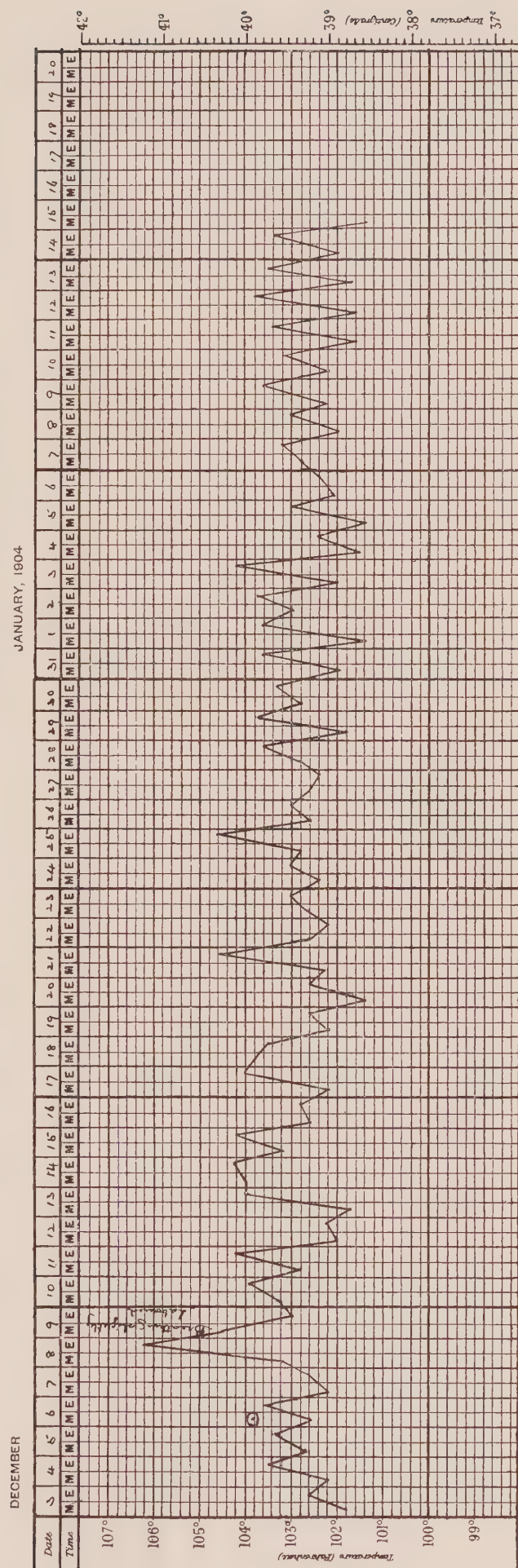
For some days, however, the temperature was slightly higher than that of the control pigs.

He gained in weight and condition constantly afterwards, and on January 12th is fattening.

The excreta collected at the moment of defæcation, 27 hours after feeding, failed to induce Plague in guinea-pigs when inoculated subcutaneously, and after local inflammation and threatened abscess the latter recovered.

The urine of the pig was obtained 53 hours after feeding, and .5 c.c. of the sediment was inoculated subcutaneously into the thigh of another guinea-pig.

Pig. Number 7. Lengthy Normal Record after Receiving Large Quantities of Plague Tissues. Fed on December 6th.



The temperature rose, and an abscess threatened, but the animal made a good recovery.

Pig 8.—Four months old, white, Kaffir variety. On December 18th ate greedily the spleen, lungs, liver, heart, kidneys, intestines, and the abdominal walls with groin glands of a full-grown guinea-pig, which had been inoculated with *Bacillus Pestis* four days previously.

The spleen was crowded with typical bacilli; the other organs contained a fair number of the same. Culture proved confirmatory and pathogenic for guinea-pigs. A rise of temperature occurred on the fourth day, but no signs of illness were observed. The pig ate ravenously, and remained bright and lively.

On January 12th, 1904, the animal is thriving. The chart merely shows the slight rise of temperature on the fourth and fifth days.

Pig 9.—Black, about 5 months old, of the Kaffir variety. On December 18th fed with the organs of a guinea-pig, which had been infected for the purpose on December 14th, and which died with all the macroscopical and microscopical appearances of Plague.

Bacilli were in great abundance, and cultures proved confirmatory.

No subsequent indisposition whatever was noticed in this case, and on January 10th the pig continues to thrive.

The chart approximates closely to that of the control animal.

Pig 10.—Black, 5 months old, of the Kaffir variety. Was fed on December 18th with about half the mashed organs of a guinea-pig which had been infected on December 14th, and which contained an abundance of bacilli. The usual surveillance was exercised, but no sign of illness was discoverable, and the temperature chart corresponds with those above.

Pig 11.—Black Kaffir pig, approximately 5 months old, was used as a control, and showed a normal record throughout.

III.—CALVES.

Calf 1.—A 7-months-old bull calf on November 14th received subcutaneously, behind left scapula, 5 c.c. of a 48-hours beef bouillon incubated culture of *Bacillus Pestis*. A control guinea-pig and a control brown rat were simultaneously inoculated with .5 c.c. from the same tube, and a flask of bouillon containing a few drops of ghee was also sown.

The control animals both died on November 18. Each with typical appearances macroscopically and microscopically, and cultures from the spleen of each proved confirmatory. The bouillon ghee flask developed a good crop of stalactites in 72 hours.

On November 17th the calf developed what appeared to be an intercurrent attack of diarrhoea, which may have been due to the cement floor and general chilliness of his new quarters.

The control calf at the same time showed some indisposition with slight diarrhoea.

All attempts to isolate the Plague bacillus from the streaks of blood in the excreta failed.

By November 20th the coat was again sleek, and thereafter the animal thrived.

Calf 2.—Bull, 6 months old, was drenched on November 19th with an emulsion of the thoroughly mashed-up organs of a rat which had been infected with *Bacillus Pestis* five days previously.

The emulsion contained an abundance of the bacilli, and the strain used proved highly pathogenic for a control guinea-pig.

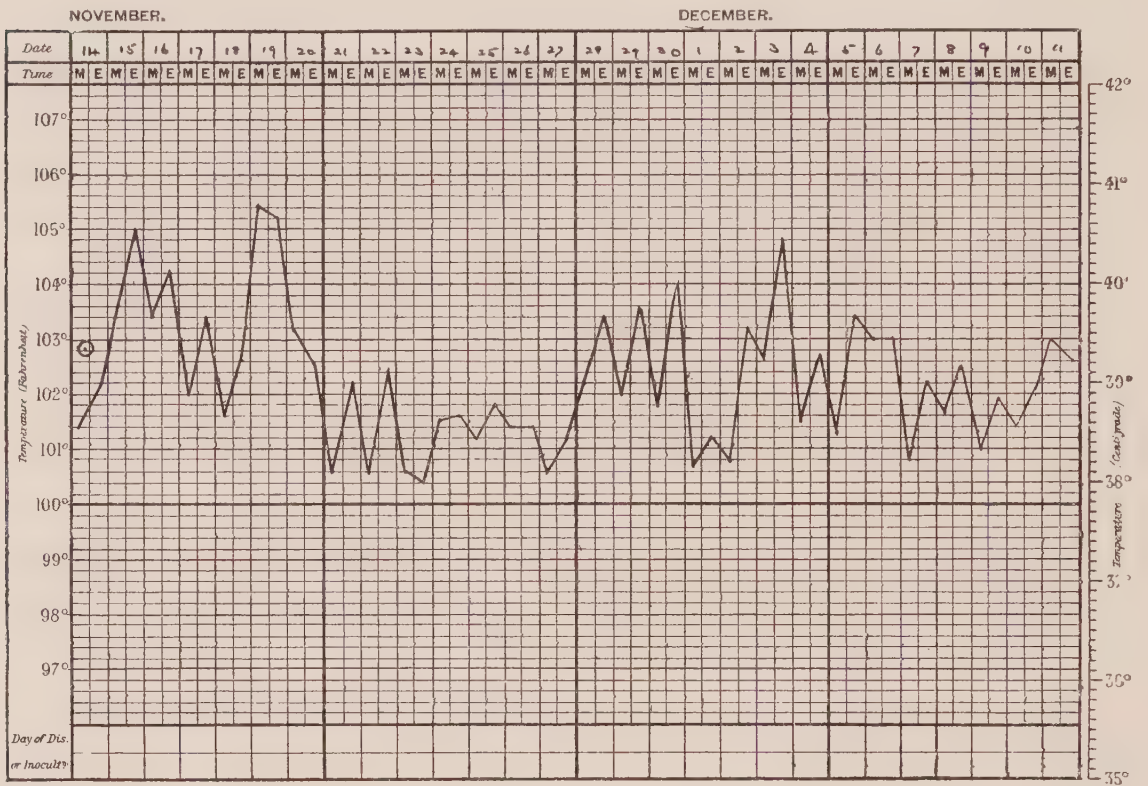
Confirmatory cultures proved positive.

This calf showed no signs of illness, fed well, and chewed the cud regularly.

At the end of a month he was discharged in improved condition.

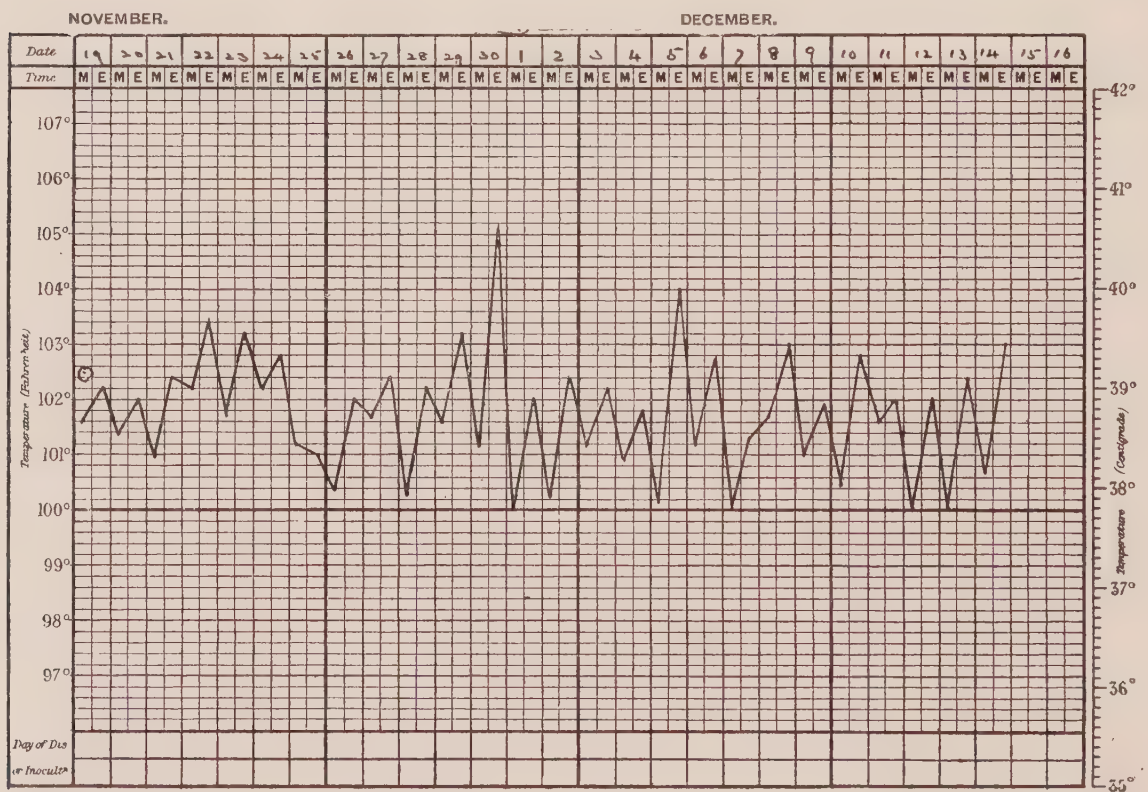
PESTIS.

Calf. Number I.—Bull Calf, about 7 months old. ☉ November 14, 1903, received behind the left scapula subcutaneously 5 c.cm. of 48-hour bouillon culture of Plague.



PESTIS.

Calf. Number II.—Brown Bull, 6 months old. ☉ November 19, fed with emulsion of Rat organs (Box 3).



APPENDIX TO PART II.

APPENDIX V.

An account of Clinical manifestations of 124 cases admitted to Durban Plague Hospital, and of 24 autopsies held there, with an abstract of principal changes found in 47 post-mortem examinations in the Public Mortuary

THE limited number of cases does not justify any general deductions, but in the clinical histories of some are found points worthy of attention.

It is customary in text-books to divide the disease into stages of prodromata, invasion, fever, adenitis, etc., but in practice it was not found possible to differentiate these.

As no cases were sent to hospital before the actual invasion of the disease, there was no opportunity afforded of studying the prodromata, and in but few cases could any reliable history be obtained, owing to the fact that the large majority were colored persons, and unable to talk English.

ONSET.

The usual history was that the patient had continued his work up to the very onset of the disease. Headache, malaise, and dizziness, with pain on locomotion or pressure, or both, over the site of the future bubo, quickly followed by prostration, were the symptoms most commonly observed. In a few the local pain preceded the constitutional symptoms, while in others it was absent. The onset was generally very rapid. Retiring to bed apparently well, or but slightly indisposed, by the morning the patient was intensely prostrate, and the disease fully established. Rigors did not occur in any from whom precise information was obtained, though feelings of chilliness were complained

of. Pains in the back and bones were complained of by nearly all the white patients and a few natives.

In the case of white patients the onset was less abrupt, and the disease was less severe, commencing with headache and chilliness, pains in the bones, with generally local pain over the site of the bubo. The constitutional symptoms rapidly became more severe, and there was an early indisposition for exercise, the patient very soon taking to bed. Sleeplessness at night was constant from the beginning. Weakness and staggering gait were observed early in nearly all cases.

All European patients, except 4, had developed buboes before admission. In 2 of these 4 a bubo appeared after admission, in 1 on the second day, in the other on the fifth day of illness, on which lobar pneumonia also developed. With these exceptions, three days was the longest period stated that elapsed from the earliest feeling of malaise until the bubo was noticed, and this period was only given in the case of these two white patients.

The bubo varied considerably in size, from a hazel nut to an egg, and was, with very few exceptions, exquisitely tender. One or more glands in a group were generally affected, and were matted together, the surrounding tissues being to a variable extent involved. The skin over the bubo was not usually reddened or adherent unless suppuration threatened.

The temperature on the day of admission was raised on an average to 103° , the pulse also increased in frequency, but, except in the very early stages, did not present sthenic febrile characters.

Respiration was also more frequent and shallow.

The skin, at first hot and dry, acted badly all through the illness.

The facies in the majority was dull and stupid, with a dazed, heavy expression, more apathetic than anxious.

The eyes were dull and the lids appeared heavy, and usually towards the close, though sometimes as early as the second or third day, became sunken and staring, the cheeks at the same time falling in. The conjunctivæ were rarely injected.

The tongue, covered (except at the tip and edges) with a white to creamy, moist fur, and generally somewhat swollen and flabby, was almost invariably markedly tremulous from the beginning. At times tremor and twitching of the lips was noted, usually associated with hesitation and thickness of articulation. Except in cases where vomiting persisted, digestion was but slightly impaired. Although constipation was the general rule, diarrhœa in a few cases was very severe.

The spleen varied greatly in size, being in a few easily palpated, while in others only slight enlargement could be made out on percussion.

The liver was usually somewhat enlarged.

Nervous symptoms were always present, all grades of intensity being encountered, from sleeplessness and restlessness, with tremor of tongue, etc., in mild cases, to furious active or low muttering delirium, with carphologia, subsultus, etc. To sum up, a patient seen at the end of the first or second day presented the following picture :—A bubo of variable size, hard and acutely tender, without apparent external cause ; pyrexia, with frequent pulse and respiration, staggering gait, or inability to stand, prostration out of all proportion to duration or apparent intensity of illness ; tongue moist, furred, and tremulous ; skin, hot and dry ; facies heavy and apathetic, with nervous symptoms of variable intensity.

COURSE OF DISEASE

When fully established the disease did not follow any fixed course.

Although the usual duration of the illness, when not terminated by death, varied from 9 to 12 days, yet in some convalescence became established earlier, while in others, although a mitigation in the severity of the symptoms occurred, the pyrexia was prolonged at a lower level for over a fortnight, without the occurrence of suppuration or any apparent cause.

In 8 cases during the acute stage there was a marked fall of temperature of from 4° to 6° between the third and sixth days, associated with an amelioration of the general condition, the

temperature, however, rising again, with a return or aggravation of other symptoms.

In 3 of these the fall and subsequent rise took place within a period of 24 hours, while in 5 the apparent improvement extended over two days. In none of these was Yersin's serum administered.

In cases likely to recover a change for the better was usually observed between the sixth and tenth days, the temperature falling by lysis and the fall associated with a gradual general improvement, frequently attended by profuse sweating.

At any time in the acute stage a rapid change for the worse might occur. Leaving a patient apparently holding his own, or even improving, one might return in 7 or 8 hours, to find the temperature raised 3 or 4 degrees with increased severity of all symptoms. Although the temperature had fallen to normal, the pulse had become more frequent and feeble, and with cold extremities and low muttering delirium, or coma, the patient sank into a state of adynamia from which he rarely rallied.

The condition in some cases became from the commencement progressively worse, the temperature at onset rising rapidly to 105° or over, and remaining elevated without remission, in association with severe constitutional symptoms.

Apart from sudden death, a fatal termination was usually approached in one of three ways :—

(1) An increase in severity of all symptoms occurred. The temperature remained high, or rose further, with increased frequency in pulse and respiration; the tongue became dry, brown, and cracked, with sordes on teeth and gums, and eyes and cheeks sunken, with anxious or vacuous expression, and delirium.

(2) In a second class the patient would be apparently progressing favourably, when a rapid fall in temperature occurred. The pulse at the same time became more frequent and feeble, the mental state usually being one of semi-coma or low muttering delirium, the whole appearance, with cold extremities, feeble fluttering pulse, etc., suggestive of collapse.

(3) In a third class the clinical appearance was that of a steadily failing heart, the mental condition varying. The pulse

became progressively weaker and more frequent, the respiration shallower, with râles at first fine and moist at the back of the lungs, gradually becoming larger, the patient but rarely attempting to cough, despite all efforts to stimulate expectoration. Occasionally thin, blood-stained, frothy, mucoid matter would be expectorated.

Complications such as secondary buboes, pulmonary lesions, nephritis, etc., occurred at different times during the acute illness, and though affecting the course of the disease, were not usually marked by any distinct acerbation in symptoms, but rather by a continuous gradual increase in severity.

Secondary buboes, arising when the constitutional disturbance was abating, were, however, followed by a return of other symptoms.

The variations in the course of the disease, and particularly the liability to rapid changes for the worse, render prognosis difficult. The majority of those who survived until the tenth day recovered.

Of 59 fatal cases in which the date of onset was precisely ascertained, 15 died between the second and fourth days, 26 on the fifth and sixth, 13 between the seventh and ninth, and 5 after the tenth day.

Of 12 other deaths which took place in the Plague Hospital, although precise information as to the day of disease is wanting, it can be said that all died before the tenth day.

SYMPTOMS IN DETAIL.

TEMPERATURE.

The general type of temperature was irregularly remittent, there being nothing constant in the curve exhibited. Usually rising somewhat abruptly, to reach the acme within 36 to 48 hours, it remained more or less elevated, with occasional marked remissions, until from the sixth to the tenth day, when it commenced to fall by lysis, reaching normal in three or four days. The ascent, though generally rapid, in some occupied two or three days. An abrupt rise, with a continuous high temperature without any remissions, was occasional, as also a continuous fall

from the second or third day to normal on the tenth or eleventh, there not being 1 degree difference between the highest and lowest temperature on each day.

As a guide to prognosis, the temperature *per se* was not reliable, for although a high temperature, if maintained any length of time, augured badly, yet a rapid fall when not associated with other sign of convalescence, and particularly if low, nervous symptoms were present, was of equally bad significance. Death occurred with a falling temperature in 12 cases.

In reference to these low temperatures, in conjunction with serious nervous symptoms, it should be mentioned that when taken in the mouth or axilla the register was very unreliable, that obtained in the rectum often indicating 4 to 5 degrees higher. However, the general import is unaffected by this, as the low surface temperature, with weak or imperceptible pulse and low nervous symptoms, clearly indicated the condition of the patient and gave warning of approaching collapse.

RESPIRATION.

The respiration, except in the very mild cases, exhibited a greater increase in frequency than would be expected from the coincident pulse and temperature. This applied to cases in which clinically no evidence of pulmonary lesions existed, and where *post mortem* nothing was noted except passive congestion.

In 30 cases (of which in 11 pulmonary lesions developed), where the temperature, pulse, and respiration were all charted, the normal pulse respiration ratio of 4 : 1 only obtained in 3, and did not remain constant in these.

In 17 (7 with pulmonary lesions) the ratio was 3 : 1, and in 13 between 3 and 4 : 1. This ratio was not always constant all through the illness, the pulse rate increasing at times without a corresponding increase in respiration, particularly towards the close.

With the occurrence of pulmonary complications the increased frequency was usually gradual and progressive.

As a guide to prognosis, its frequency was of some value apart from the indications given of complications.

CARDIAC CONDITION.

The cardiac condition all through the illness was the cause of the greatest anxiety; in fact, the treatment of the disease mainly resolved itself into the treatment of the cardiac symptoms.

The pulse rate—at least, during the first few days of illness—was not usually increased to the extent proportionate to the temperature and respiration, and but rarely presented febrile characters, being almost from the onset feeble, soft, and compressible, and later dicrotic.

In some cases this relative slowness persisted throughout the illness. While failure was as a rule gradual, occupying about two days, sometimes it came on very rapidly, the pulse-rate increasing within 4 hours from 104 to 120.

Digitalis and digitalin proved ineffectual as a remedy for cardiac asthenia.

In 2 cases arrhythmia occurred just before the lysis, and yielded very readily to digitalis.

This would seem to indicate a change in the musculature. Were a neuritis present, one would expect arrhythmia of one form or another more frequently, either during or after the illness, as not uncommonly occurs after influenza or diphtheria. In these diseases a neuritis of other peripheral nerves is also not infrequent, whereas in none of the cases of Plague which came under observation did it occur.

Peripheral neuritis has been observed, however, in outbreaks of Plague elsewhere, but it does not appear to be by any means a common occurrence.

Some degree of cardiac irritability often persisted during convalescence, the pulse increasing in frequency on slight provocation—mental or physical.

As a guide to prognosis, the cardiac condition was the most reliable.

A continuous increase in frequency in spite of stimulants or persistence of a rate of more than 120 was always of bad omen.

Of 24 necropsies performed in the Hospital Mortuary, *antemortem* clots were observed in 8.

No special symptoms during life were noted in cases in which these clots were found, although their size and firm adherence to the endocardium indicated their formation some time previous to death. Death took place suddenly in 8 cases, on 4 of which *post-mortem* examination was made.

In one of these the cause of death was asphyxia, œdema of the glottis being found *post mortem*.

In 2 cases the patients were apparently doing well when the sudden death occurred. In examination of 1 (*post mortem*) an extreme degree of cardiac dilatation was found, and in the other a considerable hæmorrhage, probably 10 ounces, was present between the layers of the mesentery and behind the parietal peritoneum on the right side, extending down to brim of pelvis. The latter patient had some degree of chronic nephritis. In the fourth the pulse had been steadily failing for two days before the occurrence, and *post mortem* the heart only exhibited a moderate degree of dilatation.

Of the 4 on which no *post-mortem* examination was made, 1, when turning in bed, had a sudden profuse flow of blood from the mouth, while in the other 3 there was no apparent cause for such a termination.

It should be mentioned that in no case had the patient been in the upright posture, and the only apparent strain that could have been put on the heart was the exertion from turning, or during delirium.

BUBO.

The bubo in all appeared early. In only 2 cases did it appear on the third day, and in 1 on the fifth.* Sometimes it consisted of a single inflamed gland, but more usually of two or three neighbouring glands of a group, matted together. A considerable amount of periadenitis was always present, varying according to the severity of the disease, and extreme tenderness was the most marked characteristic of the bubo. At first movable from surrounding structures, it soon became adherent to the

* This may be more properly called a secondary bubo, and occurred in the case referred to under Plague Hepatitis.

deep fascia, and later, when suppuration threatened, to the skin.

Apart from the periadenitis, there was in some cases an infiltration of the subcutaneous tissue for some distance around, from which the bubo was distinguished by its extreme hardness. This infiltration was of two kinds. In one it assumed the appearance of cellulitis, painful and tense at first, later becoming boggy and pitting on pressure, the skin being reddened and œdematous. This terminated generally in suppuration. In the second form, the swelling might be very large, but the ordinary inflammatory signs of redness, heat and pain would be absent. Never tense, the swelling gave to the hand a soft, semi-elastic sensation, somewhat like, though much more exaggerated than, the false sense of fluctuation obtained over large masses of fat; and it did not pit on pressure. The tendency appeared to be for a slow, continuous spread, the edge fading gradually into the healthy tissues.

As an example of the extent in a patient with an axillary bubo, the axilla, both axillary folds, all the anterior chest wall, and the corresponding shoulder and side of neck were enormously swollen.

In one such case where, by reason of a false sense of fluctuation over this puffy swelling, an incision was made, the layer of superficial fat and fascia was swollen to the extent of 4 inches, elsewhere on the body not averaging three-quarters. The appearance of the cut surface was that of an infiltration with some glairy fluid, something like the white of egg, which did not exude readily, the surface becoming dry in the course of a few hours, without wetting the dressings to any extent. This fluid gave the ordinary reactions for albumin, coagulating on heating and on the addition of nitric acid, but did not coagulate spontaneously.

Nearly all cases in which this form of infiltration appeared terminated fatally.

Buboes terminated either by (1) Resolution, (2) Suppuration, or (3) Sloughing.

(1) When resolution was commencing, the pain and tenderness

diminished, and the glands became gradually smaller, although for several days during convalescence they might still be felt matted together. Of 50 patients who recovered, resolution occurred in 25.

(2) Suppuration occurred altogether in 25 cases, of which 2 died. The days of its appearance were 4 in the first six days, 14 between the sixth and twelfth, and 7 between the twelfth and twenty-sixth. When it took place early the usual features were observed. When forming later, which was more common, the appearance was rather that of a subacute or chronic abscess. The overlying skin was frequently not reddened, or but very slightly discolored, and no signs of suppuration were present, other than fluctuation, which, commencing as a small soft spot in the centre of the hard bubo, increased gradually, and showed but little tendency to "pointing" and spontaneous rupture.

In such cases the process was really a combination of suppuration and sloughing. From the abscess when incised a variable quantity of somewhat thin, dirty-looking pus and sloughs was discharged. The walls of the abscess cavity were lined not with granulations, but with ragged, adherent sloughs, which separated very slowly; there being little, if any, neighbouring inflammatory reaction, nor could such be readily induced by applications of silver nitrate or zinc chloride. This sloughing was in some instances very extensive. In one case the entire axilla contained one large slough, extending upwards and backwards as far as the finger could reach, and forwards both over and under the pectoral muscles, in addition to which a large slough was removed from above the clavicle by a separate incision.

In most cases the temperature chart gave no indication of the occurrence of suppuration.

Although the tongue did not become quite clean, or the feeling of *bienaise* become fully established, yet in only 6 cases was there an evening rise of temperature or any pyrexia attributable to the local conditions.

Microscopically the pus consisted principally of detritus, with comparatively few pus corpuscles. Out of 6 instances in

which smear preparations were examined for bacteria, in 4 no micro-organisms of any description could be found. In 1 only (occurring on the fourth day) were typical plague germs found, this specimen also containing numerous pus corpuscles, and in 1 there were present a few scattered, large coccal forms of *Bacillus Pestis*.

(3) Sloughing—apart from that already mentioned which took place with suppuration—occurred in 3, all being inguinal buboes. One of these died on the twenty-seventh day of illness. In all 3 the bubo became extremely painful, the skin over it being adherent and intensely inflamed. Next, one or more large bullæ formed, which soon became bloodstained and burst, exposing a superficial sloughing of the dermis, which deepened until the bubo and neighbouring tissues were exposed as one large, dirty brown slough, the skin being greatly undermined at the edges. When this stage was reached, after about 3 days all pain at the site ceased, and all the surrounding inflammatory reaction disappeared, the slough lying as so much unirritating, inert matter, without any tendency to either spread rapidly or be cast off. Both in these cases and in those which suppurated the process of granulation was extremely slow, and ugly depressed cicatrices frequently remained. In smear preparations from a gland in the centre of a slough no organisms of either suppuration or Plague were seen. Two cases where suppuration occurred terminated fatally—1 on the nineteenth day, 1 on the seventeenth. One patient in whom sloughing took place died on the twenty-seventh day, a secondary pneumonia having developed. Of the 50 cases in all which recovered, suppuration or sloughing occurred in 25.

The occurrence of suppuration had a favorable prognostic significance.

SECONDARY BUBOES.

Secondary buboes developed in 11 cases, of which 5 proved fatal, 4 of these having in addition pulmonary complications. In 7 of these the glands became swollen between the third and sixth day, in 3 between the seventh and tenth, and in 1 the day of disease was unknown.

No relationship could be traced between the primary bubo and the situation in which the secondary appeared. Secondary buboes did not often attain the same degree of development as the primary, the periadenitis and surrounding involvement of tissue being usually less marked. In a few little could be detected beyond a discrete enlarged tender gland, particularly when the occurrence was late.

MULTIPLE BUBOES.

Thirteen cases were admitted to hospital with buboes in more than one situation. In 5 of these, from the previous duration of the illness and their appearance, the glandular swellings may possibly have been secondary in origin, leaving 8 instances of what appeared to be multiple primary buboes. Eleven terminated in death, 1 also complicated with bronchitis.

The situation of the 8 was as follows :—

Three inguinal both sides.

Two axillary both sides.

One axillary and groin of same side.

One axillary and groin of opposite side.

One double femoral, double axillary, and left cervical.

Before leaving the subject of buboes, attention may be drawn to the extensive involvement of a large number of glands of a group which occurred in 4 cases. Both superficial and deep cervical glands were involved, as well as the submentals. In 1 case (*post mortem*) the sterno-mastoid muscle could with difficulty be reflected, being matted to deeper structures, and all the deep glands, in various stages of necrosis, formed a dark mass beneath the muscle for its entire length. The interesting point in these cases is their simulation during life of conditions other than Plague, particularly Angina Ludovici. When associated with throat lesions and without buboes in other situations, the diagnosis is still more difficult. Of particular glands in any region, that most commonly affected in the cervical group was a gland just behind and below the angle of the jaw, and in the axilla one of the pectoral group.

PUNCTURE OF BUBOES FOR PURPOSES OF DIAGNOSIS.

In 22 cases admitted to Hospital as "suspects" the bubo was aspirated.

In smear preparations from the material thus obtained typical Plague organisms were found in 7, and in 1, though not demonstrated in the smears, cultures taken gave a positive result. Of the 14 in which no organisms were seen, 6 were diagnosed Plague, and entered as such in the returns on the evidence furnished by clinical appearance.

In 2 of these latter, although the actual day of disease when the preparation was made was not ascertained, it was apparently late, and sloughing was in progress in 1. In the remaining 4 of this group the disease ran an extremely mild course.

With regard to the diagnostic value to be attached to the negative result of bacteriological examination of buboes, the results of *post-mortem* examination of 23 buboes may here be stated.

Typical bipolar staining bacilli were easily demonstrated, usually in large numbers, in preparations from developing buboes. When the bubo was commencing to undergo degeneration, generally after six or seven days, the centre of the gland became soft, and of a dark red brown. Smears from this were, as a rule, negative, but when taken from the tissues at the periphery of the gland, generally gave positive indications of the presence of *Bacillus Pestis*. The mere fact, therefore, of not being able to demonstrate organisms in smears is not in itself conclusive of the disease not being Plague, but must be considered in conjunction with the probable age of the bubo. On the other hand, in extremely mild cases, smear preparations may not always reveal the *Bacillus Pestis*. In one case, as stated, although no organisms could be detected in several specimens examined, yet cultures gave a positive result.

NERVOUS SYSTEM.

The points of greatest interest about the nervous system were the early period at which they were manifested,

their constant presence in some degree, and usually their severity.

The earlier manifestations of perverted cerebration, which have been described by others, did not come under observation in any of the cases.

Delirium of all grades of intensity were met with—active, furious, with hallucinations, or low muttering, with carphologia, subsultus tendinum, etc.—and do not need description.

Retention or involuntary evacuation of urine and fæces were frequent, as would be expected. Attempts to get out of bed were very common, and, owing to the cardiac condition, had to be watched for. Convulsions occurred in 2 children immediately before death. *Post mortem*, nothing but slight engorgement of cortical vessels was found. Nystagmus towards the close was observed in 3, and strabismus in 3. Obstinate hiccough was present in 4, in 2 of which it ceased on the temporary withholding of the strychnine at the time being administered.

FACIES.

The facial expression, except in 11 cases, did not present marked characteristics. In the majority it was dull, stupid, apathetic, or vacuous. In the 11 it varied. In some the forehead, wrinkled transversely, with raised eyebrows, gave an appearance of anxiety, misery, or terror, while in others the vertical furrows above the root of the nose were accentuated, giving a sullen, scowling appearance.

ALIMENTARY SYSTEM.

Constipation was the rule, though in a few cases diarrhœa was present. The stools then varied in appearance; some were like pea-soup or mustard and water, others bilious. Vomiting occurred in some cases as a symptom of onset, but was more commonly met with when the disease was fully established, and proved at times a most troublesome symptom to combat. The character of the vomit was either gastric or bilious, the latter being the more troublesome and persistent. Hæmatemesis is mentioned under hæmorrhages.

PAROTITIS

was observed in 5 cases—in 3 both sides were affected ; in 2 the inflammation was confined to one side.

In 3 the primary bubo was in the neighbouring cervical glands. In 2, in which both parotids were involved, the axillary glands were affected. The swelling was noticeably visible, there being, in addition to the enlargement of the gland, some puffiness of subcutaneous tissue over it ; the skin was not tense, tenderness was not acute, nor was there any apparent difficulty in deglutition or opening the mouth. Salivation was not noticed in any case.

PHARYNGITIS

was, unfortunately, not regularly looked for, but was noticed in 7 cases. The soft palate was of a brilliant red colour, and in 3 tonsillitis was present in addition. Parotitis was present in 2 of these, and in 1 case, where during life considerable difficulty was experienced by the patient in clearing his throat of viscid mucus, the lymphoid tissue of the naso-pharynx was greatly swollen and œdematous. No bacterioscopic examination was made. In another the uvula was markedly swollen, and death was due to œdema of glottis.

SUPERFICIAL LESIONS.

In 13 of 124 cases there were primary superficial lesions, or sites of possible infection, which were as follows :—

Bleb	..	..	..	..	..	..	1
Furuncle	..	..	..	..	..	..	1
Wounds and abrasions	..	..	..	..	..	..	3
Mosquito bites	..	..	..	..	..	..	2
Bug bites	..	..	..	..	..	..	2
Conjunctivitis	..	..	..	..	..	..	1
Tonsillitis	..	..	..	..	..	..	3

Doubtless, small breaches of surface, bites of vermin, etc., were frequently overlooked, owing to the difficulty of their detection in black-skinned people. There was nothing in the appearance of the abrasions, mosquito bites, or bug bites to suggest them as the points of infection.

The lesions occurred on the surface corresponding to the lymphatic area of the buboes.

The mosquito and bug bites were scattered all over the body, but in only one instance (with mosquito bites) did buboes develop in more than one situation.

BLEB.

This patient was admitted with a bleb about the size of a half-crown on the wrist and a large bubo on the same axilla. The tissues under the bleb sloughed very deeply, exposing the tendon sheaths, and the resulting ulcer took several months to heal.

A *furuncle* was present on admission on the right shin of 1 patient—a European employed as rat-catcher—who had also a right femoral bubo. He stated that he noticed both the sore on the shin and the bubo on the day before admission. This lesion was similar in outward appearance to the secondary furuncles met with, consisting of a localised dermatitis about half an inch in diameter, hard and painful, surmounted by a bleb, there being no core as in ordinary furuncles. In smears from material aspirated from the bubo the *Bacillus Pestis* was demonstrated.

CONJUNCTIVITIS.

In this case the patient, who assisted at all *post mortems* in the town mortuary, stated that he was splashed in the right eye while assisting at a *post-mortem* examination on a case of Plague the day before admission to hospital.

Quite well up to then, he noticed the right eye sore that evening, and was admitted to hospital the following evening with cervical and preauricular buboes. He had always suffered from a tendency to sore eyes.

On admission the right conjunctiva was greatly injected, and the lids discolored, swollen, and œdematous. The left eye all through the illness showed but slight injection. The inflammation steadily increased in spite of treatment, and the lids became enormously swollen and tense. A culture taken from the chemotic exudate gave a pure growth of *Bacillus Pestis*. The

secretion all through was catarrhal, never purulent. By the seventh day the inflammation had spread to the neighbouring tissues, and all the right cheek was tensely swollen and purple.

The iris, ciliary body, and deeper structures were not affected. The case proved fatal.

TONSILLITIS.

What appeared to be a primary Plague tonsillitis occurred in 3 cases. In the first, the patient, who had been ill four days, was admitted with both tonsils and pillars of fauces sloughing, and very large cervical buboes on both sides, and a small femoral bubo on one side, which appeared to be secondary. As he had, in addition, hard and soft chancres, it was at first doubtful whether the condition might not be attributable to secondary syphilis, but in material aspirated from the bubo Plague bacilli were found. He died within 24 hours of admission. *Bacillus Pestis* was demonstrated in the gland tissue, but no bacteriological examination was made of the tonsils.

The second case occurred in a child 6 years old, who had been treated for six days previously for follicular tonsillitis, with secondary adenitis of cervical glands. On admission, a femoral bubo was developing. In fluid drawn from the gland the Plague *Bacillus* was found in great number. In this case the tonsils presented follicular ulceration and sloughing of mucosa. In the centre of each tonsil a reddish-brown lump was exposed by the denudation of mucosa, very similar in appearance to a portion of lymphatic gland affected by Plague. The cervical and submental glands of both sides were involved, the whole neck being enormously swollen and brawny, and in places pitting slightly on pressure, simulating those severe forms of angina which at times occur with scarlatina or diphtheria. Smear preparations from the tonsils, removed *post mortem*, were swarming with typical organisms.

In the third case, the patient's first complaint was of sore throat and headache, two days before admission. On examination of the throat a bright red injection of the pharynx was seen, the tonsils being only very slightly swollen. The bubo, which was in the left femoral region, appeared the day before he came

under observation—*i.e.* on the second day of illness. *Post mortem*, the tonsils did not protrude to any extent into the pharynx, but were enlarged, almost spherical, hard and tense, a little over 1 inch in diameter, and on section of a dark red brown colour, softening in places. The mucosa was intact, and the follicles unaffected, and almost obliterated, the parenchyma of the gland being alone involved. Death occurred on the seventh day, and both bubo and tonsils contained organisms indistinguishable from Plague; in the latter, they were not present in large numbers, and other bacilli were also observed.

In 3 other cases a brilliant injection of pharynx was observed, and in one of these, *post mortem*, the lymphoid tissue of the naso-pharynx was found to be extensively involved.

SECONDARY SUPERFICIAL LESIONS.

In 14 cases secondary superficial lesions were observed.

Iritis	..	..	..	..	..	..	2
Blebs over arms and legs	..	..	..	..	..	..	1
Furuncles	..	..	..	..	..	..	2
Erysipelas	..	..	..	..	..	..	1
Cellulitis	..	..	..	..	..	..	2
Petechiæ	..	..	..	..	..	..	4
Acneiform	..	..	..	..	..	..	1
Morbilliform	..	..	..	..	..	..	1

The 2 cases of iritis were both double, and terminated in complete recovery. In one, besides the irregular discolored iris, etc., there was a large solitary mass of lymph, with sharply curved outline on the upper quadrant of the iris. It was completely absorbed.

Blebs.—In this case no history was obtainable as to duration of illness, and on admission there were several bullæ on arms and legs, with right axillary and left femoral buboes. The bullæ increased in number after admission. *Bacillus Pestis* was found in the fluid of those examined.

Furuncles (2).—In neither case were they numerous. Like the primary furuncle, they consisted of a raised inflamed portion

of dermis, with a half-filled bluey-grey bleb on the top. In one case they all dried up, and in the other death occurred shortly after their appearance.

Erysipelatous rash occurred in one on the twenty-seventh day of illness, and did not appear to have any connection therewith.

Cellulitis, other than local, in the neighbourhood of the bubo, observed in 2 cases. In 1, with primary bubo in right groin, a localised cellulitis of about 3 in. diameter, terminating in resolution, appeared over back of both arms on the eleventh day.

In the other a small patch half an inch diameter appeared on right arm. Plague bacilli were obtained from this *post mortem*.

Petechiæ were present in 4, all of whom died. They took the form of small raised papules, into which a minute hæmorrhage had occurred. Of 2 examined bacteriologically during life, organisms of Plague were present in large numbers in 1. Owing to the difficulty of their detection in dark-skinned people, they were possibly frequently overlooked.

Tonsillitis.—Swollen tonsils were observed on the eighth day of illness, in 1 case on the day of the appearance of a secondary cervical bubo. Difficulty in deglutition was complained of. It subsided in a couple of days.

RENAL COMPLICATIONS.

A slight trace of albumin in the urine was not uncommon, but seemed of no clinical significance. In 7, however, the urine was loaded with albumin, in 3 of which hæmaturia ensued. *Post mortem*, in all cases varying degrees of congestion were found. In the 3 with hæmaturia the kidney approached in appearance that found in acute Bright's disease, being greatly engorged, and dripping blood in section. In one the capsule was separated with difficulty, but in the other two peeled easily. A relative cortical increase was noted. In smears from 1 the *Bacillus Pestis* was seen in profusion, but in neither of the others, although from 1 it was successfully cultivated.

PULMONARY COMPLICATIONS.

In 26 cases symptoms of pulmonary affection were noted on admission, or developed subsequently. They were as follows :—

Primary Pneumonia (died)	..	..	..	1
Lobar Pneumonia (both died)	..	..	..	2
Broncho-Pneumonia (all died)	..	..	..	7
Bronchitis (11 died)	..	..	..	15
Pleurisy—dry (recovered)	..	..	..	1

Day of the Disease on which Symptoms were First Observed.

<i>Day of Disease.</i>	<i>Pleurisy.</i>	<i>Primary Pneumonia</i>	<i>Lobar Pneumonia</i>	<i>Broncho- Pneumonia</i>	<i>Acute Bronchitis.</i>	<i>Total.</i>
First ..	—	1	.	..	..	1
Second ..	—	..	..	2	4	6
Third ..	—	..	..	2	2	4
Fourth ..	—	..	..	..	3	3
Fifth and Sixth	—	..	1	2	3	6
After the Sixth	1	..	1	1	3	6

Only 1 case of Primary Plague Pneumonia was admitted. The patient died within an hour or two of admission. He was admitted with violent delirium, and was extremely cyanosed, with shallow, quick respiration. On auscultation, owing to sounds produced in the larynx, nothing definite could be detected. There was no expectoration after admission; there were no buboes. Of the other cases, in 1 no bubo was found anywhere; in a second, bubo and signs of pneumonia appeared simultaneously on the fifth day; in the remainder a bubo was present, when the pulmonary lesion was observed.

In one instance Secondary Lobar Pneumonia appeared on the fourteenth day of illness. This patient was admitted on his eighth day of illness with right femoral bubo. A secondary cervical bubo appeared on the ninth, small furuncles on arms and legs on the tenth, cellulitis over back of both arms on the eleventh, and pneumonia of left base on fourteenth day. Death ensued on the twenty-sixth day. The sputum on the day on which signs of pneumonia were first detected was reddish grey, very scanty,

had not the viscosity of pneumonic sputum, and contained in smear preparation numerous bacilli similar to those of Plague. Subsequently the sputum was muco-purulent, and no distinctive bacilli could be seen. In the second case, admitted 6 hours after onset with no buboes, signs of pneumonia over the right base were detected on the fifth day, and at the same time a small supraclavicular bubo was noted. The sputum was reddish, not frothy, and sank in water. It had not the viscosity of ordinary pneumonic sputum, and was brighter red in colour. In specimens great numbers of what appeared to be Plague Bacilli were observed. On the next day it was frothy, mucoid, and bright blood stained, but never profuse. The patient died on the seventh day.

Broncho-pneumonia was present in 7. Two of these during life were diagnosed only as bronchitis. Although they all exhibited symptoms of acute pulmonary distress, cough was frequently absent. The sputum was in no way characteristic, and smear preparations were unsatisfactory, owing to the large variety of other organisms present ; but, *post mortem*, there were found abundance of Plague Bacilli in the nodules.

In 15 bronchitis was indicated by râles and rhonci all over both lungs. Those cases with only râles at the back of the lungs at first are not included, this being attributed to the cardiac condition.

HÆMORRHAGES.

Apart from petechiæ and small effusions of blood around the buboes, hæmorrhage occurred in 6 cases.

One hæmoptysis, the patient dying suddenly on its occurrence.

One intra-mesenteric, the patient dying suddenly on its occurrence.

One slight hæmatemesis, the patient recovering ; and

Three hæmaturia, already mentioned.

HEPATITIS.

This lesion was observed in only 2 of the cases admitted. Both were of the crew of the s.s. *Zingara*, a cattle-boat then in the harbour, from which a man, removed to the Government

General Hospital three days previously and dying there shortly after admission, was shown *post mortem* to have died of Plague.

The history of this case briefly was : The man (Tulear) had only been once ashore on May 22nd, first felt ill on 27th, removed to Government Hospital on 29th, and died that same day. *Post mortem*, a femoral bubo was found, and a condition of the liver similar in naked-eye appearance to those about to be described. In the juice from the gland *Bacillus Pestis* was demonstrated.

Of the 2 admitted to Plague Hospital, Bebe M. N., aged 24, first felt ill on May 27th, complaining of headache and pain in the chest. He had never been ashore. He was sent to Plague Hospital on June 1st, being the sixth day of disease.

Condition on Admission.—Temperature, 102.4° ; respiration, 34, shallow; pulse, 104, extremely weak, soft, and dicrotic.

Facies.—Eyes bright, expression cheerful. Talks distinctly. Mental condition clear. Tongue covered with yellowish white fur, clean at extreme tip and edges, not tremulous. Too weak to walk. Râles all over both lungs. Friction rub at back of right base. No dulness on percussion. No tubular breathing, though the râles are small, high-pitched, and sticky, not actually crepitant. Petechial papules scattered over back, chest and abdomen.

Abdomen.—Tympanitic, no tenderness anywhere, gurgling in right iliac fossa. Spleen palpable. Bowels opened by enema. Urine loaded with urates. No buboes anywhere. E.T. 103.2° . Pulse, 124; respiration, 38.

June 2nd.—No sleep last night. T., $103-4^{\circ}$. Pulse, 148; respiration, 65. Passed two pea-soupy stools. Urine clear, slight trace of albumin. No buboes. Mind clear. In evening much worse. T., 105° ; respiration, 86; pulse, “running.” Improved slightly, after infusion of normal saline solution. Temperature at 10 p.m., 103.2° , fell to 100.2° at 2 a.m. Pulse, 148 (about). Mental condition quite clear. Lungs unchanged.

June 3rd.—Temperature, 101.6° . Respiration, 74; pulse, running. Heart sounds very feeble, and both alike in quality, with shortening of “long pause.” Mental condition still clear.

Eyes bright, pupils dilated. Became rapidly worse, and died 11.50 a.m.

Post Mortem.

No buboes anywhere.

Thorax.—Both lungs exhibit broncho-pneumonia, feeling to the hand like a bag of large shot. Surrounding the superficial nodules, which are raised above surface, are areas of dark blue collapsed lung. At back of right base nodules have fused to form a larger mass of consolidation about 2 inches square. Left base in front exhibits small recent pleurisy with fresh lymph. Cut section, the nodules stand above surface level, and are reddish grey in colour. General surface exudes a bloody froth.

Heart.—Greatly dilated and very flabby. On holding up by base with apex upwards, the heart sinks over, and overlaps the fingers like a mushroom. All cavities dilated. Both mitral and tricuspid orifice admit four fingers and a bit of thumb. Valves apparently healthy.

ABDOMEN.

Spleen.—Greatly enlarged, and intensely congested and friable.

Kidneys.—Slightly enlarged and congested.

Bowels.—Injected, but mucosa apparently normal.

Mesenteric Glands exhibit no pathological change.

Liver enlarged and intensely congested, of dark purple colour, and scattered all through it in large numbers are yellowish white nodules, varying in size from that of a pea to a small hazel nut, and showing on surface a faint mapping into areas.

On section, they have a wavy outline like a corpus luteum, and the appearance of organised tissue, with no visible surrounding zone of inflammation. Not encapsuled, but firmly united with, though sharply demarcated from, adjacent liver tissues.

Gall-bladder nearly empty.

Bacteriology.—Smears from petechiæ during life negative.

Spleen.—Repeated examinations revealed no organisms in smears, but cultures gave a scanty growth, from which a guinea-pig was inoculated and died of Plague.

Hepatic Nodules.—Swarming with *Bacillus Pestis* from cultures of which guinea-pigs were inoculated and died of Plague.

Nodules in Lung.—Swarming with *Bacillus Pestis*.

The second case. Male Mauritian—Bœuf—aged 50. Ill 6 hours, with headache and pain in axilla. Admitted June 1st.

Condition on Admission.—Temperature, 101.4° ; pulse, 76; respiration, 27. Facies dull, eyes suffused. Tongue moist, furred, and tremulous. Gait unsteady; speech clear. No bubo in right axilla, in which he complains of pain. Fluid aspirated from one of the pectoral glands examined with negative result. Slight chronic enlargement of inguinal glands, which are discrete and not in the least tender. Old gonorrhœa. Spleen enlarged, not palpable. E. T., 102.2° ; pulse, 98; respiration, 30.

June 2nd.—T., 99° ; pulse, 69; respiration, 22. No headache. No pain in axilla, and appears generally brighter. Temperature rose without remission to 103.6° in evening. Pulse, 98; respiration, 30. Two watery motions after calomel. Headache. Lungs quite clear.

June 3rd.—Much the same, slight cough.

June 4th.—In evening, breathing over right base high-pitched, not tubular, and subcrepitant râles. Sputum mucoid.

Puffy, elastic swelling above right clavicle.

June 5th.—Tongue very tremulous. Pleuritic rub at right base in ant-axillary line. Expectoration reddish, not frothy, sinks in water, has not viscosity of pneumonia, and is a brighter red. In smear preparations *Bacilli Pestis* found in numbers. Swelling above right clavicle increased, and three or four small glands palpable, but not tender nor matted.

Liver greatly enlarged and acutely tender.

In evening pleuritic rub extended in area. Slightly impaired resonance on percussion, not amounting to absolute dulness and bronchophony.

In evening great hepatic pain on inspiration or coughing. Sputum blood-stained, mucoid, frothy. Spleen palpable and tender. Mind clear.

June 6th.—Much worse. In great pain. Liver 4 inches below costal margin and acutely tender. Tubular breathing.

Right mid-axillary line at level of nipple, with friction rub and crepitant râles. Bowels open. Stools like mustard and water. Considerable swelling above right clavicle, semi-elastic, not pitting on pressure, and three or four glands, the largest size of hazel nut, palpable, tender, but discrete. No other buboes.

June 7th.—Died at 4 a.m.

Post Mortem.

Middle lobe of right lung pneumonic, as is also back of upper lobe. Remainder of lung congested, as is also the left.

Spleen enlarged, dark colour, and very soft. Laid on the table, it loses its edges, and looks like a bag of fluid. On section, centre is diffuent, of a reddish brown.

Liver.—Similar to the last cases, but nodules only size of a pin-head to about three times that size.

Mesenteric glands apparently normal.

Four of five discrete glands above right clavicle slightly enlarged, slight periadenitis. On section they are a mottled, reddish brown colour, and in 1 a minute hæmorrhage.

BACTERIOLOGY.

Spleen.—Negative in smears and cultures.

Pneumonia.—Swarms of Bacilli like Plague.

Cervical Bubo.—Swarms of Bacilli like Plague.

Bronchial Glands.—No Plague Bacilli found.

Nodules in Liver.—Swarms of Bacillus Pestis.

In the first of these 2 cases, though admitted as a suspect, a provisional diagnosis of enteric was made. The mental condition all through was peculiar. Although the physical signs indicated a very severe illness, yet almost to the last the patient remained cheerful, and was always enquiring when he would be allowed back to work. The condition appeared analogous to that described in puerperal septicæmia, where, although dying, the patients state they feel quite well.

The second case presented less difficulty in diagnosis, but owing to the absence of buboes, pulmonary conditions, or anything pointing to septicæmia, the condition was regarded rather as probable than certain.

HISTOLOGY, ETC., OF HEPATIC LESION.

In sections made at right angles to surface of liver, when examined with a low power, the nodule appears sharply outlined from the adjacent hepatic cells, which seem compressed at the periphery of the lesion, although in places the columns of cells spread into it for a short distance. Where it has reached the surface, the capsule of the liver is attenuated and protrudes slightly beyond the general surface level.

Under a higher power in differentially stained sections, the entire lesion appears to consist of a small round-celled infiltration, towards the periphery of which the micro-organisms in clumps almost form a distinct zone, close to, though separated from, the adjacent liver cells. These latter, in places where the lesion appears to be spreading, extend into it for a short distance, or rather the infiltration spreads in amongst the hepatic cells, which exhibit various stages of degeneration, becoming granular and vacuolated. These vacuoles, which are very large, may have contained fat, removed during process of embedding in paraffin, but no sections were made in fresh state to demonstrate this. The liver tissue, as a whole, showed marked engorgement, the capillaries between the columns of hepatic cells being greatly dilated, and containing numerous leucocytes.

In the parts apparently spreading, as indicated by the degeneration of cells, the columns of liver cells were at right angles to the growing margin, which had infiltrated the hepatic tissue, spreading apparently along the lines of the capillaries, which contained numerous leucocytes. Where the process was not spreading, the general direction of the liver columns was tangential to the margin of the growth, and the distinction abrupt; there being here comparatively little infiltration of the margin of liver tissue, the cells of which were little, if at all, degenerated, and inclined to be compressed. No remnants of liver cells remained in centre of lesion. In one or two sections, small clumps of micro-organisms could be seen in the blood-vessels, outside the edge of the nodule.

In addition to the small round cells, constituting the lesion,

there were a large number of fibro-blasts, the appearance in parts being that of an extremely ill-defined connective tissue.

The degenerated hepatic cells, though for a time retaining their outline, appear reticulated, the protoplasm disappearing and leaving a mere skeleton of a cell.

TREATMENT.

Treatment may be divided into general and specific.

The former does not require any detailed account, being on the same general principles applicable to all acute febrile conditions. From the nature of the illness, the necessity for the symptomatic treatment of conditions likely to exhaust the patient, such as sleeplessness, delirium, vomiting, etc., is evident.

Of drugs, strychnine appears of service. Infusions of normal saline were at times of marked temporary benefit, both in rallying from an adynamic state, and in improving the general condition.

SPECIFIC—YERSIN'S SERUM.

Whether it be due to an inherent weakness in the serum or to changes undergone in its transit through the tropics, the results obtained from its use were, on the whole, unsatisfactory, although at first sight the figures may seem to indicate otherwise. The serum was administered by hypodermic injection only. Of the 124 cases admitted to hospital, 61 were treated with serum, of whom 33 died, and 63 without serum, with 39 deaths, making a mortality respectively of 54 and 62 per 100. It should, however, be remembered, as contributing to the higher mortality where serum was not used, that its administration was withheld in 10 cases owing to the patient being moribund on admission.

Perhaps the most potent cause of the apparent better results with serum was that this division includes all the white patients admitted, numbering 14, of whom only 3 died. If these be excluded, and the results obtained solely from its use in natives be taken, the results are :—

With serum, 47 cases, with 30 deaths, equals

Mortality, 63·82 per 100.

Without serum, 63 cases, with 39 deaths, equals

Mortality, 62 per 100.

With regard to its possible effect in diminishing the severity of the attack, preventing the onset of complications, and prolonging, if not saving, life, the following table does not show it to have been of any assistance :—

Effect of Yersin's Serum on Course of Disease.

	<i>With</i>	<i>Without</i>
Developing pulmonary complications ..	9 (7 died)	5 (4 died)
Admitted with pulmonary lesions ..	4 (all died)	8 (6 died)
Developing secondary buboes	7	4
Number of deaths in first three days ..	4	4
Number of deaths in second three days ..	16	16
Number of deaths in third three days ..	6	9
Number of deaths after 12th day ..	3	2

In 4 cases with serum and 10 without in which death occurred the day of disease was unknown.

A more accurate idea will be obtained of the results from Yersin serum by taking the day of the disease on which it was administered, with the resultant mortality.

Day of Disease when Serum was Administered.

<i>Day of Disease.</i>	<i>No. of Cases.</i>	<i>Deaths.</i>	<i>Recoveries.</i>
*First	6	4	2
Second	14	10	4
Third	19	10	9
Fourth	8	2	6
Fifth	4	2	2
Seventh	1	0	1
Eighth	4	1	3
Unknown	5	4	1
<i>Total</i>	61	33	28

* In 1, death occurred in 24 hours.

Of 4 cases admitted on their first day of illness in which serum was not used, only 1 died.

Of 9 on their second day, 8 died—2 suddenly and 2 on day of admission.

Of 11 on their third day, 7 died—2 within 24 hours of admission.

Post Mortem.

* *Post-mortem* examinations were performed on 24 of those who died in hospital, the general appearances being those found after any acute febrile condition—*i.e.* swelling and congestion of viscera.

There was remarkably little wasting as a rule.

A slight amount of infiltration of connective tissue of anterior mediastinum was frequent, causing an emphysematous appearance, from inclusion of air on reflection of sternum. Petechiæ of serous membranes were almost invariably present. Heart showed various degrees of dilatation and loss of muscular tone. Lungs were invariably congested behind. From the unequal distribution it would appear that the congestion in some cases was of an active description.

A colloid-like substance was observed in 4, 2 of whom had broncho-pneumonia. It was firmly incorporated with the visceral pleura, and in 2 was present between two lobes of a lung. In all 4 it was present in considerable amount. [This was also observed by Mr. Jones, District Health Officer, Stanger, in 3 instances.]

Spleen.—Besides being congested, was usually extremely friable.

Liver.—Congested, and condition of gall-bladder variable.

Mucosa of stomach exhibited a patchy ecchymosis in a few cases where vomiting was severe, but the connection was not constant.

Bubo.—Generally consisted of more than one gland.

On section, the more recently affected glands were of a reddish color, mottled with grey; when older they appeared uniformly dark red brown, softening in the centre. That their size is in

* Much delay occurred in the erection of a mortuary, and, for want of suitable accommodation for *post-mortem* work, autopsies could not be undertaken on the earlier cases.

TABLE SHOWING DOSE OF SERUM, DAY OF DISEASE ON WHICH ADMINISTERED, AND THE OCCURRENCE OF COMPLICATIONS.

<i>Day of Disease.</i>	<i>Dose Administered.</i>	<i>Dose Repeated.</i>	<i>No. of Cases.</i>	<i>No. of Deaths.</i>	<i>Recoveries.</i>	<i>Apparent Effect of Administration.</i>	<i>Pulmonary Complications Developed.</i>	<i>Bubo.</i>
First.	40 c.c.	..	4	3	1	In 1 disease was aborted	In 2 broncho-pneumonia	..
	40 c.c.	20 c.c. on the 7th day	1	0	1	Temp., etc., normal in 3 days, remained so 7 days, then recrudescence	..	..
	50 c.c. (intravenous)	40 c.c. on 2nd	1	1	0	Temp., improvement, 12 hours	..	..
	40 c.c.	..	2	2	0	Nil	..	..
Second.	40 c.c.	20 c.c. on 3rd	1	0	1	Disease ran a mild course	..	..
	40 c.c.	20 c.c. on 3rd, 20 c.c. on 4th	5	2	3	Improvement in 1, no apparent effect in 4	..	1 Secondary
	20 c.c.	20 c.c. on 3rd	1	1	0	Nil	..	..
	60 c.c.	..	2	2	0	Nil	..	..
	60 c.c.	60 c.c. on 3rd	1	1	0	Nil	..	..
	60 c.c.	60 c.c. on 3rd, 40 c.c. on 4th	1	1	0	Nil	Bronchitis	..
	60 c.c.	60 c.c. on 3rd and 4th, 40 c.c. on 5th	1	1	0	Nil	Bronchitis	..
	20 c.c.	..	3	3	0	Nil	..	1 Secondary
	20 c.c.	20 c.c. on 4th	1	0	1	Disease ran a mild course	..	..
	20 c.c.	20 c.c. on 5 succeeding days	1	0	1	Nil	..	Secondary
Third.	..	..	5	2	3	In 2 steady improvement, with recrudescence on 10th	..	..
	40 c.c.	..	..	..	..	In 2 no effect	..	..
	..	..	..	..	..	In 1 temporary improvement, then sudden death	..	..
	40 c.c.	20 c.c. on 4th	2	2	0	Nil	..	..
	40 c.c.	20 c.c. on 4th and 5th	2	0	2	Nil, in 1 recrudescence on 14th	..	Secondary

TABLE SHOWING DOSE OF SERUM, DAY OF DISEASE ON WHICH ADMINISTERED, AND THE OCCURRENCE OF COMPLICATIONS (Continued).

Day of Disease.	Dose Administered.	Dose Repeated.	No. of Cases.	No. of Days.	Recoveries.	Apparent Effect of Administration.	Pulmonary Complications Developed.	Bubo.
Third (continued).	50 c.c.	140 c.c. in 3 doses on 4th, 40 c.c. on 5th, 6th, and 7th 80 c.c. in 2 doses on 4th 40 c.c. on 5th and 6th 20 c.c. on 4th and 5th	1	0	1	Pestis Minor	..	..
	60 c.c.		1	1	0	Nil]	Bronchitis	..
	60 c.c.		1	1	0	Nil	..	..
Third (continued).	100 c.c. in 2 doses.	20 c.c. on 4th, 5th, 7th and 14th	1	1	0	Nil	Bronchitis	..
	100 c.c.		1	0	1	No immediate effect	..	..
	20 c.c.		1	0	1	No effect in any	..	..
Fourth.	40 c.c.	40 c.c. twice daily on 5th and 6th 40 c.c. M. and E. 5th, 60 c.c. on 6th 60 c.c. M. and E. on 5th and 6th 60 c.c. on 5th	3	1	2	No effect in any	In 1 Bronchitis	1 Secondary
	80 c.c. in 2 doses.		1	0	1	Steady improvement	..	..
	40 c.c.		1	1	0	Steadily worse	..	..
Fifth.	40 c.c.	60 c.c. M. and E. on 5th and 6th 60 c.c. on 5th	1	0	1	No effect	..	..
	60 c.c.		1	0	1	Nil	Bronchitis	..
	100 c.c. in 2 doses.		1	1	0	Nil	..	..
Fifth.	40 c.c.	20 c.c. on 8th and 9th	3	1	2	I ran a mild course	..	..
	40 c.c.		1	0	1	Nil	..	Secondary
	40 c.c.		2	0	2	Nil	..	..
Eighth.	20 c.c.	20 c.c. on 10th 4 hourly to 10th 60 c.c. M. and E. of 10th, etc.	1	0	1	Nil	..	..
	40 c.c.		1	0	1	Nil	..	..
	60 c.c.		1	1	0	Nil	Pneumonia	Secondary

part due to congestion is indicated by the reduction which occurred after death.

Hæmorrhages were found both around and in the bubo.

In only 2 cases with femoral buboes was there an extension to the intra-abdominal glands ; in both a gland just above the crural opening was affected.

This absence of successive involvement of neighbouring groups of glands was noted when secondary buboes were present, pointing to conveyance of infection by blood rather than lymphatics.

In a child aged 6 there was present a large thymus gland containing numerous Plague organisms, and breaking down in the centre like a bubo.

Among bodies examined at the Town Mortuary, in 47 the cause of death proved to be Plague.

In 31 no buboes were noted. In 7 of these there were pulmonary changes. In 24 there was no distinctive alteration in any organ, though there was some degree of congestion of lymphatic glands in most.

Of pulmonary lesions there were 3 lobar pneumonia, 1 broncho-pneumonia, 1 hæmothorax with collapse of lung, 1 hæmorrhagic pleurisy (with colloid material), and 1 congestion of one lung. The hæmorrhagic pleurisy was peculiar, involving only the parietal layer of pleura, which was thickened to the extent of half an inch, infiltrated with blood, the intercostal muscles being also blood-stained. A large mass of colloid-like material was present between two of the lobes of the lung, which presented no other pathological changes.

In the pleural fluid numerous Plague bacilli were found.

